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RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Navy Department

WATER LOADS ON THE XJL-1 HULL AS OBTAINED IN LANGLEY IMPACT BASIN

TED No. NACA 2413.3

By

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SUMMARY

An investigation was conducted in the Langley impact basin of the water loads on a half scale model of the XJL-1 hull whose forebody has a vee bottom with exaggerated chine flare.

The impact loads, moments, and pressures were determined for a range of landing conditions. A normal full-scale landing speed of 86 miles per hour was represented with effective flight paths ranging from 0.6° to 11.6°. Landings were made with both fixed trim and free-to-trim mounting of the float over a trim range of -15° to 12° into smooth water and into waves having equivalent full-scale length of 120 feet and heights ranging from 1 to 4 feet.

All data and results presented in this report are given in terms of equivalent full-scale values. Summary tables and illustrative plots are used in presenting the material.

The following maximum values of load and pressure are those which are apropos for effective flight paths less than 6.5°, which was the maximum value obtained in tests with the XJL-1 hull model representing full-scale landings with vertical velocity of 4.5 feet per second into 4-foot waves:

The maximum local pressure on the flat portion of the bottom is 130 pounds per square inch which was measured on a 2-inch-diameter circular area near the step. The maximum local pressure obtained in the curved area near the chines is 200 pounds per square inch. This

[redacted]

pressure was also measured near the step. At points toward the bow maximum local pressures are less than those occurring near the step. There is also a decrease in pressure magnitude from the keel toward the chine on the flat portions of the bottom.

The average distributed pressures on large areas of flat plating comprising one-third of the semiforebody bottom are about four-tenths of the maximum local pressure obtained in the same area. Average pressures on plating intermediate in size between the 2-inch-diameter circular areas and one-third the area of the semiforebody bottom are approximately estimated by straight line interpolation between the maximum local pressure in the small area and the average distributed pressure on the large area embracing the considered region.

The maximum vertical load factor is 6.4g which was obtained in a landing involving the step region. The maximum horizontal load factor of 3.6g and the maximum rotational acceleration of 12.6 radians per second per second were obtained in landings involving the pulled-up bow region.

It was observed that an increase in wave height and also an immersion of the reversed chine resulted in an increase in over-all water load; whereas freedom-in-trim during an impact resulted in a slight alleviation of local loads, particularly in bow-first landings, as compared to loads obtained with fixed trim of the float.

INTRODUCTION

Considerable interest is exhibited by designers in the magnitude and distribution of water loads which are imposed on hull bottoms during landings. In the past, the Langley impact basin has done extensive work in determining the over-all loads on a standard vee-bottom float over a range of flight paths. The tests have all been made in smooth water with the float held at a fixed trim throughout an impact.

At the request of the Bureau of Aeronautics, Navy Department, in a letter dated March 27, 1945, Aer-E-2422-TFK, an investigation has been conducted of the water loads on the XJL-1 float, whose forebody has a vee-bottom with exaggerated chine flare. The purpose of the investigation was to determine the maximum pressures, over-all loads, and moments which were imposed upon the float during water impacts.

The XJL-1 airplane is a sea-rescue amphibian which is expected to operate in comparatively severe seaway conditions. Because of this some of the impacts of the float model on smooth water were made at high flight paths to simulate landings on the steep slope of a wave. In addition, landings of the model were made at normal flight paths into waves.

Part of the impacts were made with the float mounted free to trim to provide load data under conditions as closely representative of actual landings as possible.

The results obtained from these tests provide specific load data for the XJL-1 float and provide a rough evaluation of the effect of wave height and freedom of trim upon impact loads.

APPARATUS AND INSTRUMENTATION

(All dimensions cited in this section pertain to the model tests.)

The half-scale model of the XJL-1 hull used in the tests was of all-metal construction. The structural members in the float bottom were the same size as those used in the full-scale airplane and were therefore considerably overstrength. The vee portion of the bottom had an angle of dead rise of 20° except in the pulled-up bow region, and the forebody was characterized by exaggerated chine flare which extended from the step to the pulled-up bow.

The full-scale XJL-1 hull lines are presented in figure 1 and two photographs of the model are shown in figure 2. Other pertinent information concerning the XJL-1 hull and the half-scale model is given in table I.

The standard apparatus of the impact basin described in detail in reference 1 was used during the tests. It consists principally of a catapult, a launching carriage to which the float is attached during each run, and an arresting gear. In addition to the apparatus therein described, the present test incorporated the use of a wavemaker which consists of a reciprocating flapper driven by an aircraft engine through a gear train and crank. The generated waves progressed at a velocity of approximately 15 feet per second in a direction opposite to that of the model.

The float model was attached to the carriage at three points during the fixed trim tests. The two main front support points were on a transverse line through the location of the center of gravity of the airplane and 9 inches above the center of gravity of the float. The third support point was located about 20 inches aft of the main supports and was fixed by a link of such length as to provide a given trim during a run. Wire strain gages were mounted on this link during several of the fixed-trim runs in order to measure pitching moment.

The float was supported at the two main front points during free-to-trim tests. It was held at a fixed trim prior to contact by means of a locking mechanism. After contact it was free to rotate about the transverse line through the center of gravity of the airplane over a trim range of -6.5° and 22.5°. Beyond those limits the float was restrained in angular displacement by two shock struts which were attached 60 inches fore and aft of the main pivots as shown in figure 3. The buffer action extended the trim range 5° in each direction before a stop was reached.

A dynamometer or load-measuring truss was installed between the float and the carriage support points in free-to-trim tests as shown in figure 4. This truss was a tubular structure with vertical, horizontal and transverse members oriented so that they were subject to the respective force reactions at the support points. Wire strain gages were mounted on the tubes and each installation was enclosed within metal bellows which were hermetically sealed and which contained a dehydrating agent to eliminate excessive moisture.

Two strain-gage accelerometers of the same type of construction were electrically connected to obtain angular acceleration directly. These accelerometers were located on a longitudinal line passing through the main transverse axis of rotation and at a distance of 6 feet fore and aft of the pivots. Each accelerometer had a natural vane frequency of 10 cycles per second.

A standard NACA three-component accelerometer was used to obtain the vertical component of over-all load of the float. It had a natural vane frequency of 21 cycles per second and a critical damping of 0.8.

A similar accelerometer was used to measure horizontal acceleration of the carriage and float from which the horizontal component of the over-all load was computed. It had a vane frequency of 13 cycles per second.

The instruments used to measure horizontal and vertical displacement and horizontal and vertical velocity were the same standard instruments described in reference 1.

A control-position transmitter was adapted to the basin equipment to measure angular displacement as shown in figure 5.

Sixteen induction-type electrical pressure gages were used to measure water pressure on the bottom. Their locations are indicated in figure 6 and specified in table II. A photograph of several of the gages in place in the hull bottom is given in figure 7. The measuring diaphragm of each gage was 1 inch in diameter and had a natural frequency of 500 cycles per second. It reacted linearly over a range of 0 to 80 pounds per square inch.

An electrical wave meter was located on the side of the tank to obtain approximate wave profiles. It consists of a number of electrical contacts spaced at 1- inch intervals on a vertically mounted steel tube. The wetting of successive points with the rise and fall of the water line with time was indicated on a record so that an incremental time history of the vertical displacement of the wave was provided.

TEST PROCEDURE

The total model weight ranged from 1680 to 1800 pounds which corresponds to a gross weight of the full-size airplane of 13,440 to 14,400 pounds. The mass of the model was distributed so that the scaled pitching moment of inertia of the airplane was maintained during free-to-trim tests.

During the immersion process, the weight of the model was counterbalanced by a lift engine so that a wing lift of 1g was simulated throughout the impacts.

The test conditions which were investigated are given in table III. The range of the effective trims which was covered was from -15° to 12° and the range of flight paths which was covered was from 0.6° to 6.4° with a forward speed corresponding to a full-scale landing speed of 86 miles per hour. Two runs were made at a forward speed lower than the scale speed in order to obtain flight paths of 11.2° and 11.6°. These runs were made at fixed trims of -3° and 0° and simulated landings on the flank of a wave at normal flight path. The generated waves used in all but one run of the rough-water tests were representative of full-scale waves 120 feet in length and approximately one to 4 feet in height.

The general test procedure, as described in detail in reference 1, consists of placing the launching carriage bearing the test float in firing position, catapulting the carriage, tripping the dropping weight mechanism so that the float falls freely to contact the water at a given velocity. The impact takes place, and finally, the carriage is arrested.

The tests were divided into two main parts. The first portion consisted of runs made with fixed trim mounting of the float into both smooth water and waves. The second portion consisted of runs made with free-to-trim mounting of the float into both smooth water and waves.

PRECISION OF DATA

All data obtained during the model tests have been converted to apply to the full-size airplane. The magnitudes of the different variables are considered accurate within the following limits:

Vertical displacement, inches	±0.5
Horizontal velocity, feet per second	±0.5
Vertical velocity, feet per second	±0.2
Vertical and horizontal acceleration, ratio of measured acceleration to acceleration of gravity	±0.3
Resultant force, pounds	±2000
Angular displacement, degrees	±0.5
Angular acceleration, radians per second per second	±1.0
Pressure, pounds per square inch	±2.0
Wave height, feet	±0.1

TABLES OF SYMBOLS

V velocity, feet per second

F hydrodynamic load, pounds

γ flight path, degrees

τ trim, angle between float forebody keel and reference (horizontal unless otherwise stated), degrees

β angle of dead rise, degrees

ρ mass density of water, 1.972 slugs per foot^3

n_i impact load factor, multiples of gravity

ϕ angle of line of action of F, with respect to the vertical, degrees

d vertical displacement, inches

I_o pitching moment of inertia of airplane around airplane center of gravity, 19,410 slug feet^2

l arm of F, respect to airplane center of gravity, feet

x horizontal distance of point of application of F to airplane center of gravity, feet (determined graphically from data)

P water pressure, pounds per square inch

α angular acceleration, radians per second^2

M pitching moment around transverse axis through airplane center of gravity ($M = I_o\alpha = Fl$ + moment due to float c.g. being offset from airplane c.g.), pound feet

θ wave incline (at point of contact) to horizontal, degrees

(underlined values are maximum)

Subscripts:

v in vertical direction

h in horizontal direction

e effective, referring to plane of water surface (V_e is normal to water surface)

n_k normal to keel at step

c time of contact

k referring to keel line at step

PRESENTATION OF RESULTS

The results of the tests are presented in the form of tables and illustrative plots. They should be considered to apply directly to the specified test conditions. All results have been converted to apply to the full-scale airplane landing at a horizontal velocity of 86 miles per hour. The conversion factors used for the different variables are listed in table I.

Maximum local pressures for all of the wetted pressure gage stations in each run are presented in table IV. An envelope of these maximum values obtained during the tests is presented in figure 8(a).

Time histories of the pressures which were measured by several of the pressure instruments on the forebody during four typical smooth water runs with fixity of trim are presented in figures 9 through 12. These time histories have been used in constructing three-dimensional plots of pressure distributions at different depths of immersion for the same typical impacts, and these distributions are presented in figures 13 through 16. The afterbody was not included since it usually lies in the wake left by the forebody and receives little or none of the over-all water loads.

Inasmuch as the limited number of pressure instruments were widely scattered, interpolation and extrapolation of data was required between the measured values and beyond them to obtain a plausible pressure distribution over the entire wetted area of each considered impact. This was accomplished by assuming that the pressure distribution in a transverse line and in a longitudinal line maintains the same general shape on the flat portion of the bottom with change in time or depth of immersion during any particular impact. Also use was made of the fact that the water-line pressures decrease with immersion proportionally as the square of the decreasing velocity of the water normal to the keel.

Gages 4 and 5 and gages 10 and 11 (see fig. 6) are symmetrically spaced and in the absence of pressure results from one, pressures on the symmetrical gage are substituted.

The maximum horizontal and vertical impact load factors which were obtained are presented in table V. The maximum resultant loads and angular accelerations which were obtained are given in table VI. The pitching moment as listed is the product of the measured angular acceleration and the pitching moment of inertia of the airplane, 19,410 slug feet squared.

Time histories of trim, angular acceleration, resultant force with its horizontal and vertical components for the ten heaviest impacts with freedom in trim, are given in figures 17 and 18.

DISCUSSION OF RESULTS

Water Pressures

The water pressures which were investigated fall into two general classifications. The first type is the local pressure such as was sustained on the small circular area of the pressure gage diaphragm. The second type may be called an average distributed pressure. This is defined as the total water load imposed on an area, such as between bulkheads, divided by the area to give an average pressure which is considered to be evenly distributed over the area. The latter type is the one most pertinent to bottom plating design since the local pressures are directly applicable only to areas of about $\frac{1}{8}$ square inches.

Local pressures.- The envelope of the maximum measured local pressures presented in figure 8(a) is based on the results given in table IV and covers all of the test conditions. In using it to define the recommended local pressures for hull design certain alterations are in order.

For instance, the local pressures that were obtained near the keel in the step region are recommended for use from the step to the bow region. This is advisable because in landings in waves it is possible to obtain initial impacts anywhere along the forebody keel. In this case the velocities of the impinging water normal to the keel and, therefore the local pressures anywhere along the forebody keel, may be as great as that which exists in the step region.

Furthermore, it is apparent that a reduction in the pressures shown in figure 8(a) on the chine area of the forward half of the forebody is permissible. This is obvious from the free-to-trim results which do not render as high values in this region as those obtained in fixed-trim tests. Apparently, the hydrodynamic moment which arises in a bow landing results in an increase in trim so that the forward chine area is never heavily loaded.

This alleviation in local pressures due to freedom in trim does not extend to the keel region, for the bow pressures obtained in the fixed-trim tests in that region were equaled or exceeded in free-to-trim runs in which the bow entered the flank of a wave. Impact 2 is an example, in which a sustained local pressure of 72 pounds per square inch was indicated on the extreme bow gage number 16. During impact 1, which was also a bow impact, no pressure record was available but the overstrength keel at the bow was noticeably dented. No such failure occurred in any other impact so that pressures greater than any of the recorded pressures in the bow region are applied. Therefore, the bow pressures which were obtained near the keel in fixed-trim tests on gages numbers 14 and 15 which are adjacent to the extreme bow gage are recommended as being valid for design purposes.

In accordance with these observations, figure 8(a) is altered to provide an envelope of recommended local pressures. These so-called recommended design pressures, which are presented in figure 8(b) may be considered as the maximum local pressures which are likely to occur in the operating conditions of seaway, trim, and flight path covered by these tests.

Average pressures.- The average distributed pressures which are ultimately sought for design purposes are those values which should be applied to any stringer or section of plating to provide the maximum load to which the structure should be designed. The principal loaded region which is of interest is the flat vee portion of the forebody bottom.

One means of determining these average distributed pressures for any desired area is to establish the relationship between the average distributed pressures which occur on the wetted area at time of maximum force in an impact, to the maximum local pressures which were registered during the impact on the portion of the flat plate being considered.

Four impacts having trims of -3°, 0°, 7°, and 10° are studied in detail as typical examples showing the growth of wetted area and the change in the water loading distribution on the bottom during an impact.

The interpolations and extrapolations which were made in forming the three-dimensional plots, given in figures 13 through 16, are justified by comparing the integrated pressures with the measured over-all loads,at the time of maximum force, as noted on the plots. The agreement was found to be satisfactory.

These plots are used in estimating the average distributed pressure on the wetted part of the flat portion of the bottom at the time of maximum over-all load. The affected areas and the computed average distributed pressures for the semiforebody are listed in table VII. It was found that the average distributed pressure at time of maximum force was about four-tenths of the maximum local pressure which was obtained on the flat portion of the bottom during impact.

Using this relationship, figure 8(b) is then used to estimate the approximate design value of average distributed pressure which should be applied to any area of bottom plating intermediate in size between the small circular area and the larger areas which are loaded at time of maximum force in an impact.

The area of flat plate which is loaded at the time of maximum force is generally about one-third of the total of the forebody flat plate area or about 1500 square inches on the semiforebody. This is arbitrarily taken as the mean wetted area on the semiforebody to which the average distributed pressures, which are four-tenths of the maximum local pressure in that wetted region, apply.

If it is desired to find the recommended design value of the average distributed pressure on a particular section of flat plating, the maximum local design pressure for that area is obtained from figure 8(b) and it applies to an area of approximately 3 square inches (the area of the pressure-gage diaphragm). The average distributed pressure for a 1500 square inch area in which the considered flat plating is centrally located is computed by taking four-tenths of the maximum local pressure in the larger region. A linear interpolation is then made to obtain the average distributed pressure on any area intermediate in size between the 3 and 1500-square-inch areas; and an extrapolation is made for an area greater than 1500 square inches.

For example, if it is required to specify the average distributed pressure on an arbitrary area such as that cross-hatched in figure 8(B) the suggested procedure is followed. The maximum local design pressure in this area is 80 pounds per square inch (which applies to 3 square inches of plating). The maximum local design pressure in the 1500 square inches within which the prescribed area lies is 130 pounds per square inch. Therefore the average distributed design pressure is 40 percent of 130, or 52 pounds per square inch. The area of plating with which we are concerned is 640 square inches and the corresponding interpolated average distributed pressure is 68 pounds per square inch.

The procedure may be varied slightly when using figure 8(b) to determine the average distributed pressure on longitudinal strips. Instead of interpolating in terms of areas, the interpolation may be made on the basis of wetted widths. The reason for this is that the cited figure was evolved from measured local pressures on three longitudinal rows of pressure gages, each row lying on a strip of plating 2 inches in width.

For example, it is desired to specify the average distributed pressure for the design of an 8-inch strip adjacent to the keel and extending from the bow to the step. The design pressure for the 2-inch strip adjacent to the keel is the average of the local pressures presented in figure 8(b) or 120 pounds per square inch.

The design value of average distributed pressure on a 7-inch strip adjacent to the keel with an area of 1500 square inches is again 52 pounds per square inch. Therefore the extrapolated average distributed pressure for the design of the eight-inch strip is 38 pounds per square inch. If the extrapolation is made on the basis of areas, as in the first example, a slightly higher value, of 41 pounds per square inch, is obtained.

This suggested procedure of interpolation or extrapolation between or beyond local pressures and average distributed pressures provides only a rough approximation of the desired design pressures on an area. The preferable method of determining panel loads would be to insert measuring panels of various sizes in different locations so as to measure the loads directly over a range of test conditions. In the absence of such instrumentation, the local pressures measured by the pressure gages have been interpreted as discussed in an effort to provide an approximation of the loads which should be applied to different portions of the XJL-1 hull bottom.

The afterbody is not considered in detail because it usually lies in the forebody wake and therefore is not subjected to very great loads. The average distributed pressure on the afterbody may be assumed to be one-half of the afterbody maximum local pressure, for conservative design.

Over-All Loads

The load factors which are presented in table V specify the magnitude of the inertia load which must be considered in the design of concentrated weight supports, such as engine mount, pilot's seat, attachments, etc., and are pertinent in over-all hull design.

The maximum vertical load factor was 18.9g which was obtained in a run with fixed effective trim of 0° and with an effective flight path of 11.5°. The impact simulated the flat contact of the float against the flank of a wave.

The maximum horizontal load factor was 6.8g which was obtained in a run with fixed effective trim of negative 3° and an effective flight path of 11.3°. The impact simulated a bow impact against the flank of a wave.

Both of these runs appear to be representative of full-scale landings into waves if in such landings the peak load is reached before the trim changes appreciably. However, the data from this test are too limited to verify or disprove this postulate.

The applicability of the loads for design purposes also depends upon the probability of effective flight paths of about 11° being reached in landings in waves. In examining table V, it is seen that no flight paths of greater than 6.5° were reached in forebody impacts in waves with freedom of trim of the float model. Therefore, this flight path is taken as the upper limit likely to be reached in the specified seaway conditions.

The maximum vertical load factor obtained in this scope of flight paths was 6.4g which was obtained in an impact involving the step region. The maximum horizontal load factor was 3.6g which was obtained in a bow impact in 4-foot waves.

In landings in higher waves or in hard impacts with lower horizontal velocity (such as those following a bounce), higher flight paths would be reached and the higher loads reached in the fixed trim runs might well be equaled. On the other hand, since the resultant velocity is less, the peak loads would be accordingly less.

Therefore, for the parts of the test most representative of the actual landing condition (with the ~~airplane~~ free-to-trim in impacts in 4-foot waves), the lower values obtained at flight paths less than 6.5° may be taken as the maximum design values. The higher values obtained at higher flight paths may be used for more severe landing conditions such as are represented in impacts 4, 9, 14, and 15.

The maximum pitching acceleration was 12.6 radians per second per second, which was obtained in a bow impact, while the maximum diving acceleration was 8.5 radians per second per second, which was obtained in an afterbody impact.

The values of angular acceleration and vertical and horizontal load factor may be coupled disregarding phase relationship for a conservative design of different structural components. The appropriate values of effective trim which are given in table V may be used to convert the horizontal and vertical components of load (given in tables V and VI) to drag and normal components.

By studying the time histories of trim, angular acceleration, and load, given in figures 17 and 18, the phase relationship between the several measured quantities may be estimated. For instance, it is evident that the maximum vertical load factors do not accompany the maximum horizontal load factors. Also, the maximum angular acceleration usually lags the maximum vertical force.

Comparison of Experimental Results with Impact Load Theory

It is of interest to note whether the pressures and loads vary in a manner defined by current impact theory. If approximate agreement exists the pressures or loads for conditions other than those investigated may be computed in the manner described in references 2 and 3.

Wagner deduced an equation for the maximum local pressures on vee-bottom floats, in terms of initial velocity, as given in reference 2, formula (6). This formula has been altered for use of instantaneous velocities to eliminate any question as to the accuracy of the formula when initial velocities are used, as discussed in the reference. The modified equation is

$$p = \frac{\rho}{2 \times 144} V_{n_k}{}^2 \left(\frac{\pi}{2} \cot \beta\right)^2 \tag{1}$$

Impacts which involved principally the prismatic section of the forebody are used in the comparison which is presented in figure 19. It is found that experimental maximum local pressures on the flat portion of the bottom approximately agree with those computed using equation (1) and hence this equation may be used to determine maximum local pressures.

Maximum load factors are defined in reference 3. In figure 2 of this reference a load-factor coefficient is plotted against flight path. Substitution is made for weight, trim, dead rise, and velocity and the appropriate load factor is obtained from the load-factor coefficient for the different flight paths. The defined values are computed on the basis that no chine curvature exists and a comparison of defined and experimental loads is presented in figure 20.

The measured loads are found to average about 50 percent greater than the theoretical loads. This is because the maximum measured loads occurred after chine immersion. However, in viewing the general trend of the load variation with flight path as given in figure 20, the relationship defined in reference 3 is observed to be approximately followed.

Loads for impacts with chine immersion having different flight paths, trims, or velocities from the ones investigated may be computed by using the proper values in figure 2 of reference 3. Since the loads on the XJL-1 were 50 percent greater that the theoretical loads this ratio should then be applied to obtain the desired load factors.

Loads in impacts in which the chines of the XJL-1 are not immersed may be taken as approximately the same as those defined in figure 2 of reference 3 for vee bottom floats with angle of dead rise approximating $22\frac{1}{2}^{\circ}$.

Comparison of Results for Smooth Water and Rough Water

Since much of the data was obtained from runs made with high flight path into smooth water for simulating contact on the flank of a wave, it is desirable to compare these runs with corresponding impacts in waves.

A comparison of maximum local pressures and load factors for several runs having comparable effective trims and effective velocities of penetration at time of contact is presented in table VIII.

In examining the pressures on the gage which was wetted just after contact of the hull (gage 15 in impacts 7 and 8, gage 3 in other impacts) it is observed that the pressures were approximately the same in corresponding runs made in smooth water and in waves. As the float penetrated deeper the corresponding pressures on the other gages were in fair agreement except in impacts 36 and 41 in which case the recorded chine pressures are considerably different. This lack of agreement is attributed to differences in local velocities at the time the chine gages were wetted.

The impacts in table VIII also have comparable wetted areas at time of maximum immersion. However, in impacts such as 14 and 15 (see table IV) where the wetted areas are appreciably different at time of maximum immersion, poor agreement is evident between pressures on corresponding gages.

A sketch showing several rough-water impacts having the same flight variables at contact but having different wetted areas at time of maximum immersion is presented in figure 21. As indicated here the later stages of the impact would be expected to be considerably different because of the variations in local velocities.

The overall loads in smooth water and in the corresponding rough water runs are found, by table VIII, to be in good agreement in cases where the wetted areas are approximately the same.

Therefore, it is apparent that one of the principal factors entering the load picture with the introduction of waves is the area involved.

Effect of Wave Height and Wave Length

Over the range of wave heights used in the tests there is a definite increase in resultant load with increased wave height, as is evident in impacts 33, 30, and 21, and in 6, 8, and 3. Also, as observed in free-to-trim tests (impacts 1 and 11, for example), the danger of severe bow impacts arose in landings in waves.

The data are not adequate to establish the effect of the wave height to wave length ratio upon water loads.

Effect of Freedom in Trim

Since part of the data was obtained from fixed trim tests it is important to determine their applicability to actual landings with freedom in trim.

This is done by comparing data from fixed-trim runs with data from free-to-trim runs having approximately the same test variables. This comparison is presented in table IX.

It is found that the over-all load factors and local pressures are in good agreement except for the pressure in the chine region near the step (gages 4, 6, and 7). As previously mentioned (in the discussion of local pressure), the results from free-to-trim tests justified the selection of recommended design values of pressure on the forward portion of the chine strip below those obtained in fixed trim tests.

The discrepancy in chine pressures near the step as shown in table IX are compensated for by two free-to-trim runs (runs 41 and 18) in which high pressures were registered in this region comparable to the fixed trim results.

No obvious effect of rotational velocity superimposed upon the center-of-gravity velocity is apparent in the measured water loads. However, to accurately establish any effect would require a careful comparison of the time histories of all variables and this is not justified in an experimental investigation of maximum water loads such as the present test.

Effect of Reversed Chines

The comparison of experimental load factors with corresponding theoretical values given in figure 20 is a clear indication of the increase in load caused by chine immersion which accompanies heavy impacts.

The effect of chine immersion upon local pressures on the flat vee portion of the forebody bottom is shown in table IV. In runs 7, 14, 19, 23, 24, 29, and 49, the local pressure on the flat plate near the chine (gage 4 or 5) was greater than the local pressure near the keel (gage 3).

For a standard vee-bottom float with no chine flare the velocity of penetration decreases with increasing immersion and the local pressures at the water line decrease accordingly.

The reason for the higher pressures on the plating near the chine of the XJL-1 hull is demonstrated in figures 9 and 10. Gages 5 and 11, which are located adjacent to the curved chine, and gages 3, 9, and 14, which are located along the keel, register two distinct peaks, which are labeled (1) and (2) on the plots. The first occurs as the water line passes over the gage and the second occurs a brief period of time after the chine gage at the same station, gage 6 or 12, registers a peak.

On gages 5 and 11, the second peak is higher than the first peak and in figure 9, the second peak on gage 5 even exceeds the maximum pressure occurring on gage 3, while in figure 10 the second peak on gage 11 exceeds the maximum pressure on gage 9. Apparently this was the case in the cited impacts in which the pressure on the flat plate near the chine exceeded that near the keel.

The second peaks are attributed to the effect of a shock wave induced by high local pressures in the reversed chine pocket which affects the bottom area aft of the water line and toward the keel.

In runs in which a change in trim takes place during the immersion process the effect of the shock wave is considerably reduced, though not eliminated.

SUMMARY OF RESULTS

The recommended maximum load and pressure results which are summarized here are apropos for the most severe condition in which the XJL-1 hull is expected to operate. These severe operating conditions are, specifically, those encountered with the airplane landing at a forward speed of 86 miles per hour and a vertical velocity of 4.5 feet per second into waves 4 feet in height and 120 feet in length.

In the free-to-trim model tests which most closely represented these specific conditions, with an effective trim range of -15° to 12°, the maximum effective flight path was 6.5° and the corresponding maximum full-scale velocity of penetration is 16.6 feet per second. These values are the limits for which the following results apply:

1. The maximum local pressures on the flat portion of the hull (fig. 8(b)) vary from 130 pounds per square inch at the keel near the step to about 70 pounds per square inch at the keel near the bow. The maximum local pressures decrease in a transverse direction to about 90 pounds per square inch adjacent to the curved chine in the step region and to about 60 pounds per square inch at the forward station near the chine where the prismatic section ends.

2. The maximum local pressures in the curved strip at the chine vary from 200 pounds per square inch near the step to 10 pounds per square inch in the forward half of the forebody (fig. 8(b)).

3. The maximum local pressures on the afterbody vary from small positive and negative values on the forward part to a positive 30 pounds per square inch near the stern (fig. 8(b)).

4. The maximum vertical load factor is 6.4g, which was obtained in an impact involving the step region. The maximum horizontal load factor is 3.6g, which was obtained in a bow impact.

5. The maximum pitching acceleration is 12.6 radians per second per second while the maximum diving acceleration is 8 radians per second per second.

CONCLUDING REMARKS

The specific test results presented in the report as interpreted in the discussion of results also provide certain qualitative information regarding loads and pressures. These qualitative observations are applicable to the XJL-1 hull over the range of test conditions covered, and are as follows:

1. The maximum local pressures on the flat vee portion of the hull bottom are approximately in agreement with theoretical values obtained by using Wagner's formula, given in reference 2, altered to apply to instantaneous velocities.

2. The average distributed pressures on areas comprising one-third of the semiforebody flat plating are about 40 percent of the maximum local pressures in the same region. The average distributed pressure on any given area of flat plating may be obtained by linear interpolation or extrapolation between or beyond the maximum local pressure in the area and the average distributed pressure on the larger area (equal to one-third of the semiforebody flat plating) within which the considered area is centrally located.

3. The maximum loads are found to occur after chine immersion and exceed by 50 percent those obtained with a standard vee-bottom float for the same test condition, as presented in reference 3.

4. It is observed that change in trim during an impact has little effect on peak load although slight local load alleviation is apparent in bow landings with freedom of trim as compared to the similar impacts in which the trim is fixed throughout the impact.

5. It is also found that an increase in wave height results in an increase in load factor.

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1. Batterson, Sidney A.: The NACA Impact Basin and Water Landing Tests of a Float Model at Various Velocities and Weights. NACA ACR L4H15, 1944.

2. Mayo, Wilbur L.: Analysis and Modification of Theory for Impact of Seaplanes on Water. NACA TN No. 1008, 1945.

3. Mayo, Wilbur L.: Theoretical and Experimental Dynamic Loads for a Prismatic Float Having an Angle of Dead Rise of $22\frac{1}{2}^{\circ}$. NACA RB No. L5F15, 1945.

TABLE I

XJL-1 FLOAT DATA

	Scale: Full	Scale: Model
Beam at main step, in.	76	38
Angle between forebody keel and base line, deg.	0[a]	0[a]
Angle between afterbody keel and base line, deg.	7.5	7.5
Angle of dead rise at step, deg.	20.0	20.0
Height of main step at centroid, in.	7.06	3.53
Center of gravity forward of centroid of main step, in.	27.33	13.66
Center of gravity forward of point of main step, in.	51.32	25.66
Center of gravity above base line, in.	72.78	36.39
Gross weight, lb	13,440 to 14,400	1680 to 1800
Load coefficient, C_Δ, (fresh wate), $\frac{\text{gross weight, lb}}{63.4 \times (\text{beam, ft})^3}$	0.82	0.82
Moment of inertia in pitch, lb in.^{2}	90 by 10^6	2.81 by 10^6

(λ is the dimensional scale factor or one-half for XJL-1)
Model values × conversion factor = equivalent full-scale value[b]

Quantity	Conversion factor	Quantity	Conversion factor
Length	$1/\lambda = 2.0$	Moment of inertia	$1/\lambda^5 = 32.0$
Area	$1/\lambda^2 = 4.0$	Velocity	$1/\lambda^{\frac{1}{2}} = 1.414$
Volume	$1/\lambda^3 = 8.0$	Time	$1/\lambda^{\frac{1}{2}} = 1.414$
Mass or weight	$1/\lambda^3 = 8.0$	Linear acceleration or load factor	$1/\lambda^0 = 1.0$
Pitching moment	$1/\lambda^4 = 16.0$	Force	$1/\lambda^3 = 8.0$
Angular acceleration	$\lambda = 0.5$	Pressure	$1/\lambda = 2.0$

[a]All trim angles measured relative to the base line which has been taken as the tangent to the forebody keel at the main step.
[b]Reference: Bridgman, "Dimensional Analysis," Yale University Press.

TABLE II

PRESSURE GAGE LOCATION

[All values are full scale]

Gage no.	Aft from bow (in.)	Port from keel (in.)	[a]Vertical from keel (in.)
1	388.42	3.70	2.26
2	308.12	3.50	2.76
3	206.04	3.70	2.26
4	206.30	27.60	10.70
5	206.34	-27.72	11.00
6	203.82	31.84	13.76
7	206.44	34.68	10.70
8	156.62	4.56	2.56
9	113.00	4.76	2.76
10	113.60	-21.00	8.26
11	112.88	21.28	8.76
12	114.12	30.88	13.70
13	114.12	34.88	10.70
14	83.62	3.52	1.58
15	37.62	3.52	1.52
16	11.50	5.72	7.60

[a]Measurements made with keel line at step in horizontal position.

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TABLE III

LANDING CONDITIONS[1]

[All values are full scale]

Impact no.	τ_c (deg)	V_v (fps)	[3] γ (deg)	τ_e (deg)	V_e (fps)	θ (deg)	[2] Wave height (ft)	File no.	Remarks
1	-8	1.2	.6	-14	16.4	6.0	3.6	7-24-45 2c	Free trim.
2	-15	12.2	5.9	-15	12.2	0	0	6-30-45 1	Do.
3	0	3.0	1.4	-6.8	20.4	6.8	4.0	6-2-45 2	Fixed trim.
4	4	4.8	2.2	-4.0	25.2	8.0	4.0	6-1-45 1	Do.
5	-3	1.3	.6	-3.0	1.3	0	0	5-23-45 2	Do.
6	-3	4.5	2.1	-3.0	4.5	0	0	5-8-45 3	Do.
7	-3	9.9	4.5	-3.0	9.9	0	0	5-17-45 2	Do.
8	0	4.4	2.0	-3.0	12.1	3.0	2.0	6-2-45 3	Do.
9	-3	25.1	11.3	-3.0	25.1	0	0	5-23-45 1	Do.
10	0	2.2	1.9	-1.5	6.0	1.5	2.0	5-26-45 2b	Do.
11	2	2.6	1.3	-1.4	11.3	3.4	3.6	7-17-45 3b	Free trim.
12	0	12.6	5.8	0	12.6	0	0	5-21-45 1	Fixed trim.
13	0	13.9	6.4	0	13.9	0	0	5-7-45 1	Do.
14	7	4.1	1.9	0	21.7	7.0	4.0	5-29-45 3	Do.
15	0	25.6	11.5	0	25.6	0	0	5-22-45 3	Do.
16	4	4.1	1.9	2	13.4	2.0	4.0	5-30-45 1	Do.
17	2	13.0	6.0	2	13.0	0	0	5-22-45 1	Do.
18	7	4.5	2.1	2.3	16.6	4.7	3.5	7-11-45 1	Free trim.
19	10	3.0	1.5	2.6	22.1	7.4	4.0	6-5-45 1b	Fixed trim.
20	6.5	3.7	1.8	3.0	12.7	3.5	3.5	7-13-45 1	Free trim.
21	7	4.4	2.0	3.3	13.7	3.7	3.5	7-13-45 2	Do.
22	6.4	4.6	2.2	3.4	12.3	3.0	2.0	7-10-45 2	Do.
23	4	9.9	4.5	4.0	9.9	0	0	5-17-45 3	Fixed trim.
24	4	13.4	6.1	4.0	13.4	0	0	5-17-45 4	Do.
25	4	13.4	6.2	4.0	13.4	0	0	5-19-45 1	Do.
26	7	3.8	1.8	4.3	10.7	2.7	2.0	5-28-45 4	Do.
27	10	3.4	1.6	7.0	11.1	3.0	2.0	6-4-45 2	Do.
28	7	3.5	1.6	4.3	10.4	2.7	2.0	7-14-45 3b	Free trim.
29	7	4.1	1.9	5.5	7.9	1.5	2.0	5-28-45 3	Fixed trim.
30	7	4.5	2.1	5.7	7.8	1.3	1.8	7-10-45 3	Free trim.
31	7	3.0	1.4	6.0	5.5	1.0	4.0	5-29-45 2a	Fixed trim.
32	12	4.2	2.0	6.3	18.6	5.7	3.6	7-17-45 3a	Free trim.
33	7.2	4.5	2.1	6.7	5.6	0.5	.7	7-9-45 1	Do.
34	7	4.5	2.1	7	4.5	0	0	7-7-45 1	Do.
35	7	5.7	2.8	7	5.7	0	0	6-29-45 1	Fixed trim.
36	7	11.3	5.3	7	11.3	0	0	7-17-45 4	Free trim:
37[d]	7	12.1	5.5	7	12.1	0	0	7-17-45 5	Do.
38	7	11.4	5.4	7	11.4	0	0	7-7-45 2	Do.
39	7	13.6	6.2	7	13.6	0	0	5-17-45 1	Fixed trim.
40	7	14.0	6.4	7	14.0	0	0	5-9-45 2	Do.
41	11.2	4.1	1.9	7.7	13.1	3.5	3.5	7-17-45 1	Free trim.
42	11.5	4.2	1.9	9.9	8.2	1.6	2.0	7-16-45 1	Free trim.
43	10	4.1	1.9	10	4.1	0	0	6-4-45 1	Fixed trim.
44	10	12.1	5.6	10	12.1	0	0	5-19-45 3	Do.
45	12	4.1	1.9	10.5	7.9	1.5	3.5	7-16-45 2	Free trim.
46	10	4.0	1.8	11.2	1.0	-1.2	4.0	6-5-45 1a	Fixed trim.
47	12	4.2	1.9	12	4.2	0	0	7-14-45 1	Free trim.
48	12	9.5	4.4	12	9.5	0	0	5-9-45 1	Fixed trim.
49	12	10.8	5.0	12	10.8	0	0	7-14-45 2	Free trim.

[a] First impact.
[b] Second impact.
[c] Fourth impact.
[d] During this run the force exerted by the lift engine was equal to 0.8 of the model weight.
[1] Symbols as listed in Table of Symbols included in main body of report.
[2] Length of wave was 120 feet except in impact 1, in which it was 60 feet.
[3] Flight paths are based on measured horizontal velocity which varied slightly from the scaled value of 86 mph due to differences in catapult powder charges.

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TABLE IV

MAXIMUM PRESSURES ON XJL-1 HULL

[All values are full scale]

Gage number				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Impact no.	τ_e (deg)	V_e (fps)	γ_e (deg)	Pressure (lb/sq in.)															
1[bc]	-14	16.4	-8	No pressure gages used.															
2[b]	-15	12.2	-15	a	5	75	51	a	18	28	24	8	6	a	7	5	5	14	72
3[c]	-6.8	20.4	0	0	0	8	5	7	13	5	a	8	a	a	3	10	a	32	0
4[c]	-4.0	25.2	4	a	a	30	24	37	43	25	a	17	a	a	33	26	a	34	0
5	-3.0	1.3	-3	0	0	0	a	0	0	0	a	0	a	0	0	3	0	23	0
6	-3.0	4.5	-3	a	a	a	a	a	a	a	a	a	a	a	a	a	a	26	0
7	-3.0	9.9	-3	0	0	4	11	7	15	7	a	11	a	a	a	19	a	34	0
8[c]	-3.0	12.1	0	0	0	a	5	7	15	8	a	8	10	a	18	13	a	27	0
9[e]	-3.0	25.1	-3	0	0	50	a	72	149	97	a	96	a	58	100	131	63	63	0
10[c]	-1.5	6.0	0	0	0	2	5	3	10	2	a	9	6	0	18	24	20	29	0
11[bc]	-1.4	11.3	2	20	a	a	a	0	13	13	11	8	6	0	3	.6	22	28	0
12	0	12.6	0	a	0	30	24	29	60	9	a	18	a	15	90	56	26	20	0
13	0	13.9	0	0	0	38	26	a	50	29	a	18	a	a	a	a	a	0	0
14[c]	0	21.7	7	a	a	31	57	42	106	a	a	29	18	15	a	a	a	a	a
15[e]	0	25.6	0	0	0	90	a	77	203	87	a	27	a	57	138	116	46	a	0
16[c]	2	13.4	4	a	a	28	a	a	14	9	a	a	a	a	a	a	a	a	a
17	2	13.0	2	a	0	46	a	41	126	91	a	5	a	0	0	0	27	0	0
18[bc]	2.3	16.6	7	a	a	59	a	a	140	a	30	21	0	0	0	3	28	2	0
19[c]	2.6	22.1	10	9	4	69	88	52	176	123	a	3	a	0	a	0	a	a	0
20[bc]	3.0	12.7	6.5	a	a	84	41	a	77	49	46	25	0	0	0	0	22	0	0
21[bc]	3.3	13.7	7	a	a	85	60	45	76	85	61	a	0	0	0	a	0	0	0
22[bc]	3.4	12.3	6.4	a	a	109	48	59	84	a	40	0	0	0	0	0	0	0	0
23	4.0	9.9	4	0	0	46	52	51	108	a	a	0	a	a	a	0	a	0	0
24	4.0	13.4	4	5	0	66	73	73	162	106	a	5	a	a	0	a	a	0	0
25	4.0	13.4	4	6	0	62	74	78	156	94	a	5	a	0	0	0	0	0	0
26[c]	4.3	10.7	7	12	0	31	46	40	91	33	a	0	0	0	0	0	0	0	0
27[c]	7.0	11.1	10	24	2	54	0	0	15	2	a	0	0	a	0	2	a	0	0
28[bc]	4.3	10.4	7	0	a	56	a	7	48	15	37	15	0	0	0	0	21	0	0
29[c]	5.5	7.9	7	11	0	33	52	45	130	36	a	0	0	0	0	0	a	0	0
30[bc]	5.7	7.8	7	a	a	43	24	17	83	14	25	16	0	a	0	0	19	3	0
31[c]	6.0	5.5	7	5	0	29	0	0	0	0	0	0	0	0	0	0	0	0	0
32[bc]	6.3	18.6	12	17	a	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33[bc]	6.7	5.6	7.2	a	a	75	0	0	0	0	0	0	0	0	0	0	0	0	0
34[b]	7	4.5	7	0	0	57	0	0	0	0	0	0	0	0	0	0	0	0	0
35	7	5.7	7	0	0	76	0	0	0	0	0	0	0	0	0	0	0	0	0
36[b]	7	11.3	7	13	a	100	73	a	91	77	42	0	0	0	0	0	0	0	0
37[bd]	7	12.1	7	19	a	130	84	84	110	79	50	0	0	0	0	0	0	0	0
38[b]	7	11.4	7	a	a	112	46	57	80	70	45	0	0	0	0	0	0	0	0
39	7	13.6	7	11	-6	124	a	84	178	98	a	0	a	a	a	a	a	0	0
40	7	14.0	7	10	-6	106	71	a	160	79	a	a	a	a	a	a	a	0	a
41[bc]	7.7	13.1	11.2	17	0	104	96	a	178	126	59	0	0	0	0	0	0	0	0
42[bc]	9.9	8.2	11.5	24	a	108	41	a	10	a	0	0	0	0	0	0	0	0	0
43	10	4.1	10	16	0	0	0	0	a	a	0	0	0	0	0	0	a	0	0
44	10	12.1	10	23	a	88	52	59	28	31	a	0	a	a	0	0	0	0	0
45[bc]	10.5	7.9	12	13	a	110	86	a	a	a	56	0	0	0	0	0	0	0	0
46[c]	11.2	1.0	10	12	0	0	0	0	0	0	a	0	a	a	a	a	0	0	0
47[b]	12	4.2	12	0	a	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	12	9.5	12	23	a	0	0	0	0	a	a	a	a	a	a	a	a	0	0
49[b]	12	10.8	12	28	a	40	49	41	91	43	52	0	0	0	0	0	0	0	0

[a]No pressure record obtained.
[b]Free trim.
[c]Landed in waves.
[d]During this run the force exerted by the lift engine was equal to 0.8 of the model weight.
[e]These runs were made at actual model forward speeds of 28.7 mph, instead of at the scaled model speed corresponding to the full-scale landing speeds of 86 mph. Therefore, a scale factor equal to the ratio of the square of their respective velocities was used to convert the measured pressures to full-scale values. Taking into consideration the conversion factor of 2 for pressure,

$$(\text{measured pressure}) \times \left(\frac{86}{28.7}\right)^2 = \text{Full-scale pressure.}$$

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TABLE V

MAXIMUM HORIZONTAL AND VERTICAL IMPACT LOAD FACTORS

[All values are full scale]

Impact no.	τ_e (deg)	γ_e (deg)	τ_c (deg)	n_{i_v} (g)	n_{i_h} (g)	Impact no.	τ_e (deg)	γ_e (deg)	τ_c (deg)	n_{i_v} (g)	n_{i_h} (g)
1[d,g]	-14	6.4	-8	3.8[f]	3.6[f]	26	4.3	4.2	7	3.8	2.0
2[b,g]	-15	5.9	-15(0)	6.2[f]	3.4[f]	27	4.5	4.4	10	2.1	2.2
3	-6.8	7.8	0	4.8	3.4	28[g]	4.7	4.1	7	1.9[f]	.9[f]
4	-4.0	9.7	4	7.5	4.0	29	5.5	3.1	7	4.1	2.5
5	-3.0	.6	-3	.4	1.2	30[g]	5.7	3.1	7	2.9[f]	.7[f]
6	-3.0	2.1	-3	1.3	1.5	31	6.0	2.2	7	1.3	1.4
7	-3.0	4.5	-3	3.3	2.2	32[g,h]	6.3	7.1	12	.1	0
8	-3.0	4.8	0	2.2	1.4	33[g]	6.7	2.6	7.2	1.4[f]	.5[f]
9[e]	-3.0	11.3	-3	18.1	6.8	34[g]	7	2.1	7	1.4[f]	.3[f]
10	-1.5	2.4	0	3.0	1.4	35	7	2.8	7	1.4[f]	.6[f]
11[g]	-1.4	4.3	2	2.2[f]	3.5[f]	36[g]	7	5.3	7	4.7[f]	1.6[f]
12	0	5.8	0	5.3	a	37[c,g]	7	5.5	7	5.9[f]	1.5[f]
13	0	6.4	0	5.3	2.2	38[g]	7	5.4	7	4.5[f]	af
14	0	8.5	7	8.1	4.2	39	7	6.2	7	6.4	2.9
15[e]	0	11.5	0	18.9	5.9	40	7	6.4	7	6.4	2.1
16	2	5.2	4	3.2	1.4	41[g]	7.7	5.0	11.2	5.9[f]	1.8[f]
17	2	6.0	2	5.7	2.6	42[g]	9.9	3.1	11.5	2.7[f]	1.5[f]
18[g]	2.3	6.5	7	5.2	1.8	43	10	1.9	10	1.2	.8
19	2.6	8.6	10	6.5	(4.5)	44	10	5.6	10	5.2	(3.5)
20[g]	3.0	4.9	6.5	4.4[f]	1.6[f]	45[g]	10.5	3.1	12	6.0[f]	2.3[f]
21[g]	3.3	5.4	7	3.9[f]	2.1[f]	46	11.2	.1	10	.6	1.2
22[g]	3.4	4.8	6.4	4.9[f]	1.1[f]	47[g]	12	1.9	12	.3	.2[f]
23	4.0	4.5	4	4.8	2.3	48	12	4.4	12	2.4	a
24	4.0	6.1	4	6.1	2.7	49[b,g]	12	5.0	12(7.4)	3.1	1.3[f]
25	4.0	6.2	4	6.0	2.8						

[a]No record obtained.
[b]Trim changed considerably before peak loads reached. ( ) value at time of peak load.
[c]During this run the lift engine exerted a force equal to 0.8 of the model weight.
[d]Oleo in trim buffer fully compressed prior to water contact.
[e]These runs were made at 28.7 mph instead of at the scaled value (60.8 mph) representing a full-scale landing speed of 86 mph. (Therefore, the measured accelerations were converted to scale values by multiplying by the square of the respective velocities, i.e., (measured g) × $\left(\frac{60.8}{28.7}\right)^2$ = Full scale g.
[f]Load factor obtained from load-measuring truss, otherwise values from three-component accelerometer are listed.
[g]Free to trim.
[h]Afterbody ticks wave crest with low effective trim.
( ) Doubtful.

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TABLE VI

MAXIMUM ANGULAR ACCELERATION AND RESULTANT LOADS

[All values are full scale]

[e]Type of impact	τ_c (deg)	V_v (fps)	[a]Wave height (ft)	F (lb)	[d]F_v (lb)	[d]F_h (lb)	ϕ (deg)	l (ft)	x (ft)	[b]α (rad/sec^2)	[b]M (lb-ft)	Impact No.
Bow	-8.0	1.2	3.6	75,800	55,000	52,000	43.5	3.8	14.5	12.5	242,800	1[c]
Bow	0	3.0	4.0	------	------	------	----	---	----	----	810,000	3
Bow	0	4.4	2.0	------	------	------	----	---	----	----	200,000	8
Bow	2.0	2.6	3.6	50,500	27,400	42,500	57.2	5.7	19.0	12.6	244,600	11
Forebody	6.5	3.7	3.5	66,000	63,300	18,500	16.1	2.4	4.0	10.0	194,100	20
Forebody	7.0	4.5	1.8	45,400	42,500	15,800	20.4	3.7	6.0	7.6	147,600	30
Forebody	6.4	4.6	2.0	74,000	70,400	22,700	17.9	2.6	4.5	7.8	151,400	22
Forebody	7.0	4.4	3.5	62,400	55,500	28,500	27.2	2.3	5.5	7.2	139,600	21
Step	7.0	11.3	0	70,400	67,300	21,000	17.3	2.0	3.8	5.5	106,800	36
Step	7.0	12.1	0	88,000	85,400	21,100	13.9	1.2	2.6	3.6	69,900	37
Step	7.2	4.5	.7	22,100	21,200	6,400	16.7	1.7	3.4	4.8	93,200	33
Step	11.2	4.1	3.5	89,400	85,600	25,800	16.8	1.0	2.7	7.2	139,800	41
Step	7.0	4.5	0	20,000	19,800	2,700	7.6	1.2	-2.0	-2.3	-44,600	34
Afterbody then step	7.0	3.5	2.0	29,000	26,800	11,000	11.9	4.4	-7.0	-5.7	-110,700	28
Do--------	10.0	3.0	4.0	------	------	------	----	---	----	----	-140,000	19
Do--------	10.0	3.4	2.0	------	------	------	----	---	----	----	-200,000	27
Rocking	12.0	4.1	3.5	------	------	------	----	---	----	-4.0	-77,700	45
to step				91,300	86,200	30,200	19.2	1.5	3.5	8.9	172,800	
Do--------	11.5	4.2	2.0	35,700	35,600	1,200	2.1	.2	-.4	-5.3	-102,800	42
				48,400	46,200	14,400	17.4	2.5	4.3	-6.8	132,000	
Rocking to	12.0	10.8	0	15,000	14,200	4,700	18.4	11.8	-14.3	-8.5	-165,000	49
forebody				35,600	34,500	8,600	14.0	5.0	6.5	10.0	194,100	
Afterbody	10.0	4.0	4.0	------	------	------	----	---	----	----	-160,000	46
Do--------	12.0	4.2	3.6	9,600	9,400	2,200	13.2	12.4	-13.9	-8.2	-159,000	32
Do--------	10.0	4.1	0	------	------	------	----	---	----	----	-170,000	43

[a]Length of wave was 120 feet except in impact 1 when it was 60 feet.
[b]– denotes nosing down, otherwise float is pitching up.
[c]Oleo in trim buffer fully compressed prior to water contact.
[d]Components of load at time of maximum resultant loads.
[e]Type of impact described according to bottom area which was loaded during impact as indicated by pressure data. See table IV.

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TABLE VII

AVERAGE DISTRIBUTED PRESSURES ON FLAT PORTION OF FOREBODY

[All values are full scale]

(Data given for semiforebody)[a]

Pressure distribution, figure number	13	14	15	16
[b]Projected area of loaded flat plate, in.^{2}	1,200	3,300	820	440
Maximum over-all load, lb (by integration of pressures)	22,500	130,000	44,000	22,000
Part of maximum load on flat plate, lb	18,000	120,000	41,000	14,500
Average distributed pressure on loaded flat plate, lb/in.^{2}	15	37	50	33
Maximum local pressure on loaded flat plate, lb/in.^{2}	34	90	124	88
Average distributed pressure/maximum local pressure, percent	41	41	40	39

[a]All data given for time of maximum force with exception of maximum local pressure which occurred just after water contact.

[b]Total projected area of flat portion of semiforebody is 5000 in.^{2}.

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TABLE VIII

COMPARISON OF SMOOTH AND ROUGH-WATER IMPACTS

[All values are full scale]

Gage number					1	2	3	4	5	6	7	8	9	11	12	13	14	15		
τ_e (deg)	V_e (fps)	Wave height (ft)	n_{i_v} (g)	n_{i_h} (g)	Maximum pressure (lb/sq in.)														Impact no.	Remarks
-3.0	9.9	0	3.3	2.2	0	0	4	11	7	15	7	a	11	a	a	19	a	34	7	Smooth
-3.0	12.1	2.0	2.2	1.4	0	0	a	5	7	15	8	a	8	a	18	13	a	27	8	Rough
4.0	9.9	0	4.8	2.3	0	0	46	52	51	108	a	a	0	a	a	0	0	0	23	Smooth
4.3	10.7	2.0	3.8	2.0	12	0	31	46	40	91	33	a	0	0	0	0	a	0	26	Rough
7.0	5.7	0	1.4	.6	0	0	76	0	0	0	0	0	0	0	0	0	0	0	35	Smooth
6.7	5.6	.7	1.4	.5	a	a	75	0	0	0	0	0	0	0	0	0	0	0	33	Rough
7.0	11.3	0	4.7	1.6	13	a	100	73	a	91	77	42	0	0	0	0	0	0	36	Smooth
7.7	13.1	3.5	5.9	1.8	17	0	104	96	a	178	126	59	0	0	0	0	0	0	41	Rough

[a]No pressure record obtained.

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TABLE IX

COMPARISON OF FIXED-TRIM AND FREE-TO-TRIM IMPACTS

[All values are full scale]

Gage number					1	2	3	4	6	7	9	11	12	13	14	15		
τ_e (deg)	V_e (fps)	Wave height (ft)	n_{i_v} (g)	n_{i_h} (g)	Pressure (lb/sq in.)												Impact no.	Remarks
-1.5	6.0	2.0	3.0	1.4	0	0	2	5	10	2	9	0	18	24	20	29	10	Fixed trim.
-1.4	11.3	3.6	2.2	3.5	20	a	a	a	13	13	8	0	3	6	22	28	11	Free trim.
2.0	13.0	0	5.7	2.6	a	0	46	41	126	91	5	0	0	0	27	0	17	Fixed trim.
2.3	16.6	3.5	5.2	1.8	a	a	59	a	0	a	21	0	0	3	28	2	18	Free trim.
7.0	11.1	2.0	2.1	2.2	24	2	54	0	15	2	0	a	0	2	a	0	27	Fixed trim.
4.3	10.4	2.0	1.9	.9	0	a	56	7	48	15	15	0	0	0	21	0	28	Free trim.
5.5	7.9	2	4.1	2.5	11	0	33	52	130	36	0	0	0	0	a	0	29	Fixed trim.
5.7	7.8	1.8	2.9	.7	a	a	43	24	83	14	16	0	0	0	19	3	30	Free trim.
7.0	14.0	0	6.4	2.1	10	-6	106	71	160	79	a	a	a	a	a	0	40	Fixed trim.
7.0	11.3	0	4.7	1.6	13	a	100	73	91	77	0	0	0	0	0	0	36	Free trim.
7.7	13.1	3.5	5.9	1.8	17	0	104	96	178	126	59	0	0	0	0	0	41	Free trim.
7.0	13.6	0	6.4	2.9	11	-6	124	84	178	98	0	a	a	a	a	0	39	Fixed trim.
7.0	12.1	0	5.9	1.5	19	0	130	84	110	79	0	0	0	0	0	0	37[c]	Free trim.
12	9.5	0	2.4	a	23	a	0	0	0	0	a	a	a	a	a	0	48	Fixed trim.
12	10.8	0	3.1 1.5[b]	1.3	28	a	40	49	91	43	0	0	0	0	0	0	49	Free trim.

[a]No pressure record obtained.
[b]For part of impact corresponding to impact 48. (See fig. 18.)
[c]During this run the lift engine exerted a force equal to 0.8 of the model weight.

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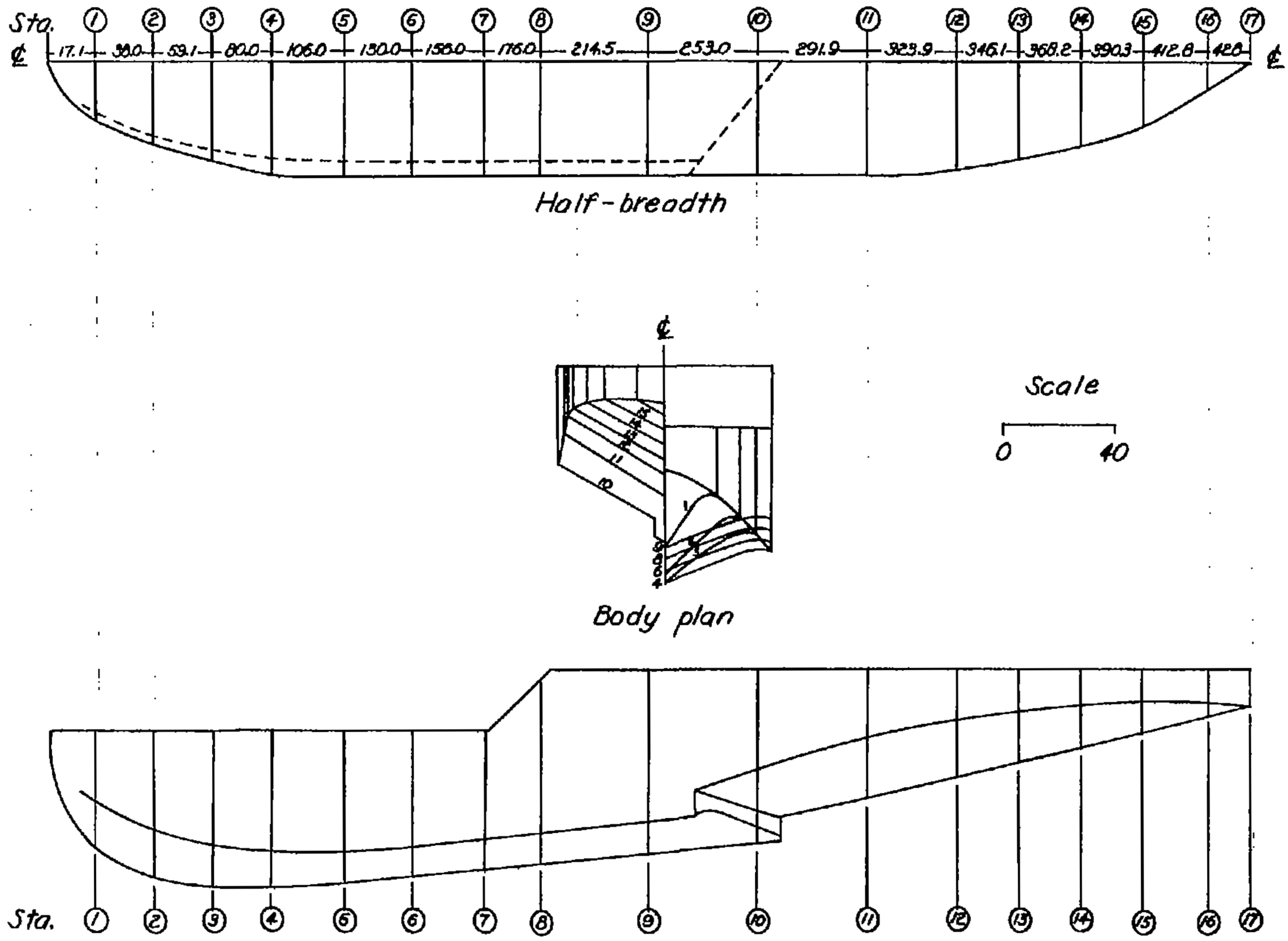

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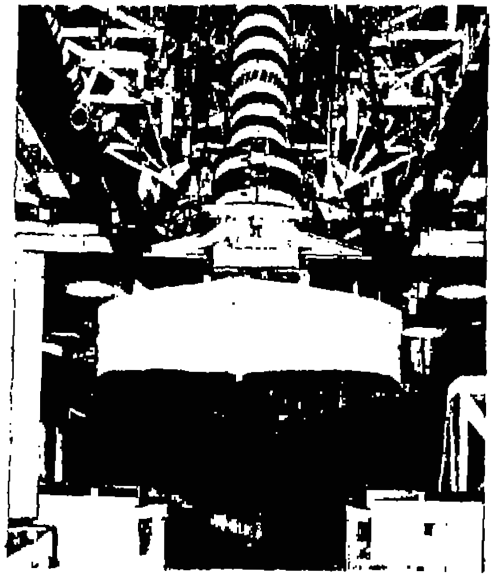
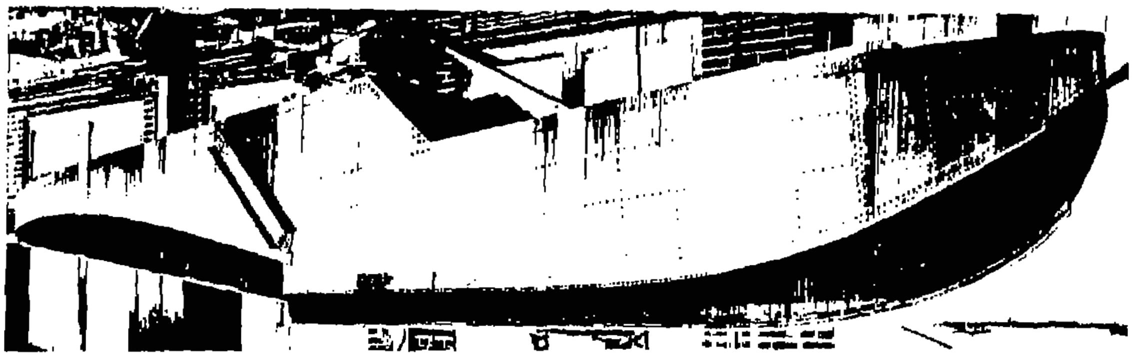
Figure 1. - Lines of XJL-1 float model (full scale dimensions).



(a) Stern view.



NACA RM No. L6I03

(b) Side view.

Figure 2.- Photographic views of XJL-1 float tested in Impact Basin.

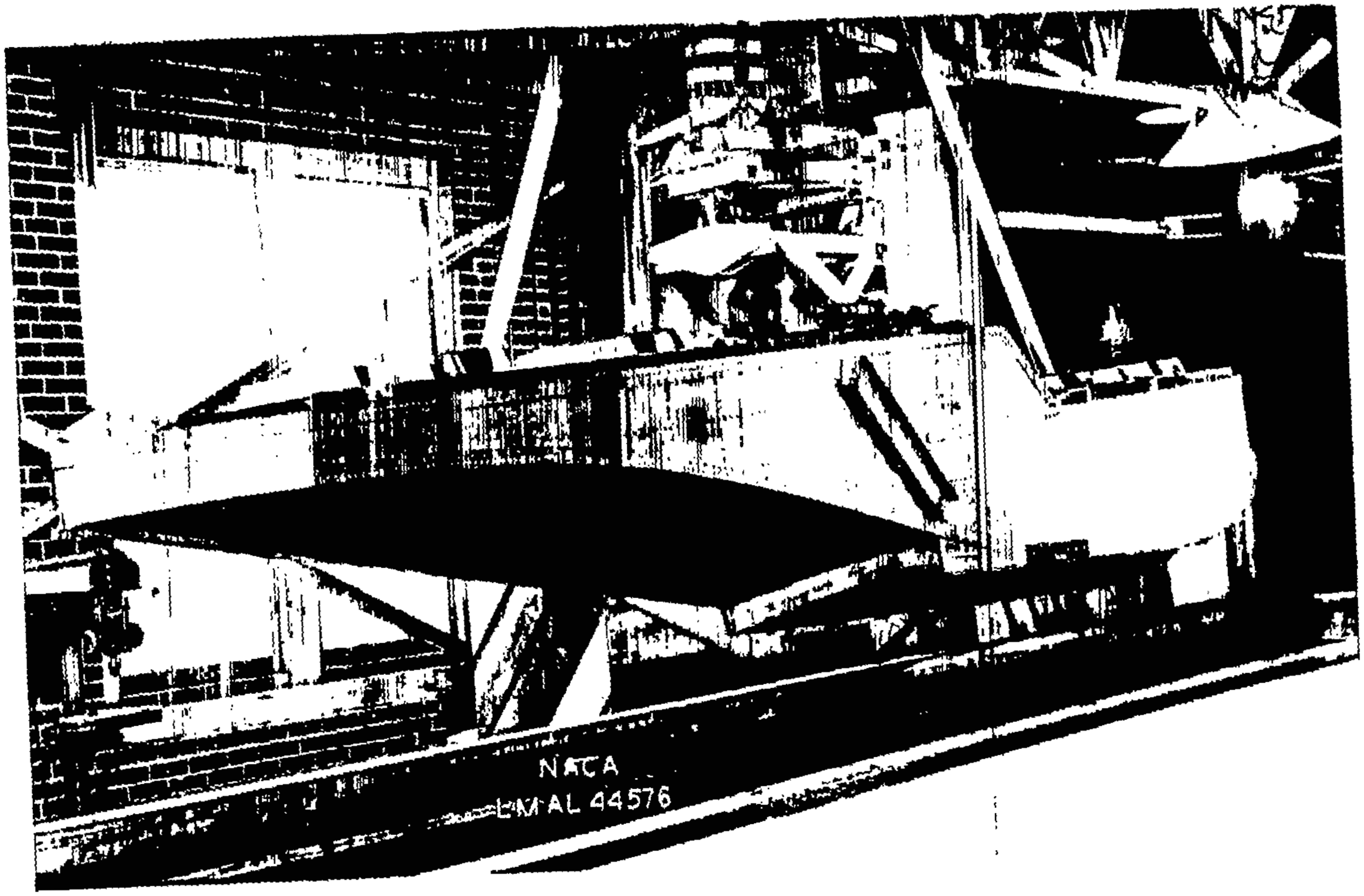


Figure 3.- XJL-1 float as tested with freedom in trim.

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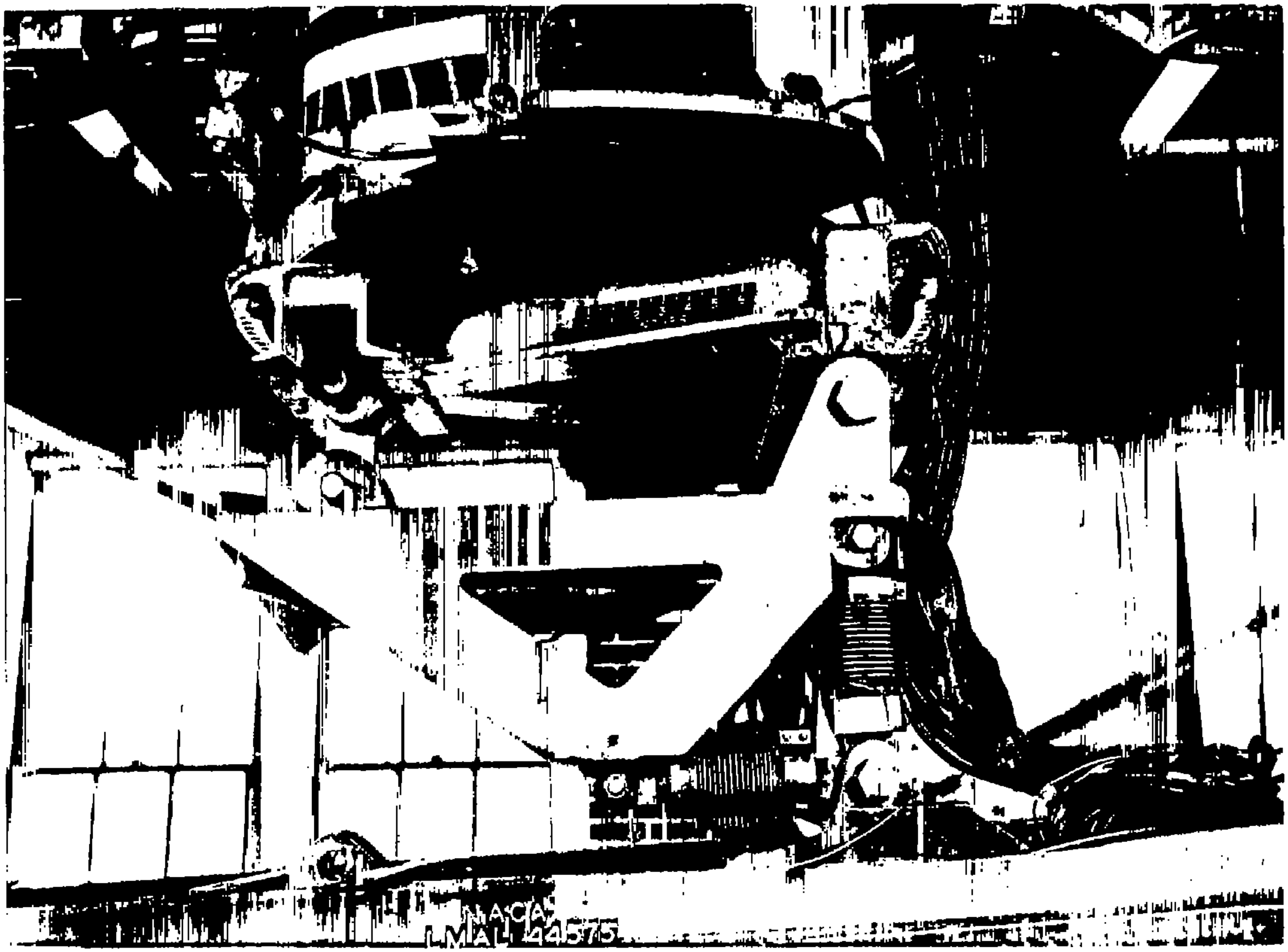

Figure 4.- Side view of load measuring truss used in XJL-1 tests.

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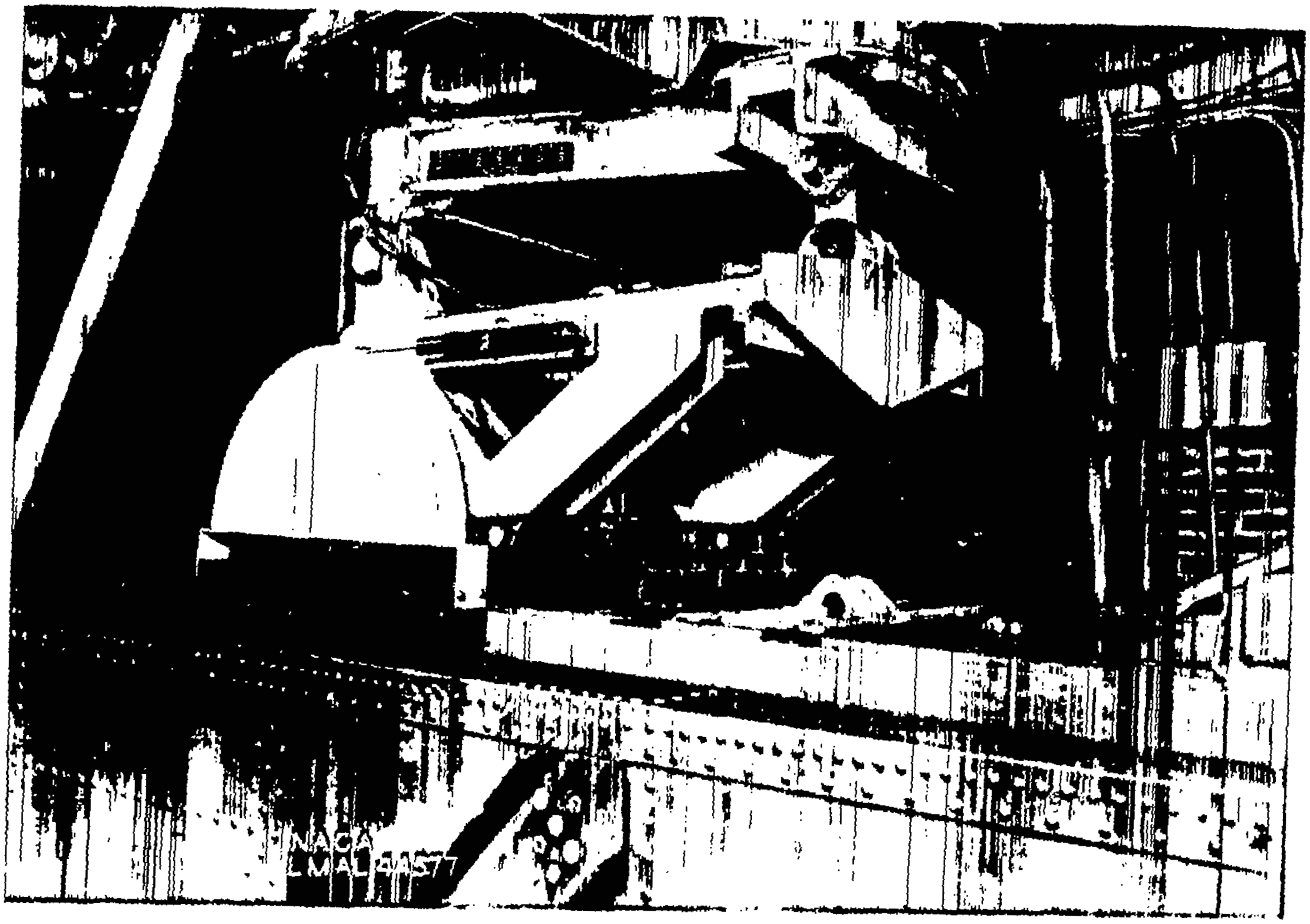

Figure 5.- View of control-position transmitter adapted to measure angular displacement.

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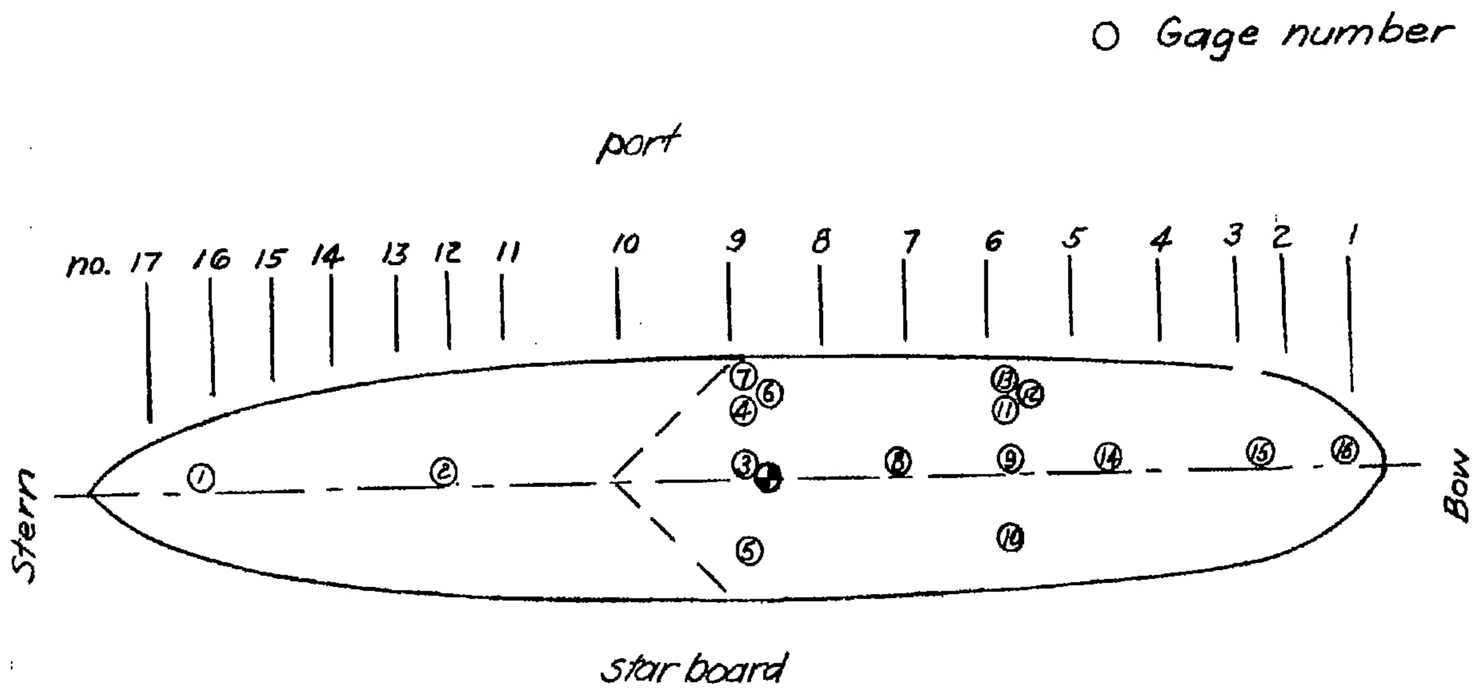

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Figure 6.- Pressure instrument location on XJL-1 float.

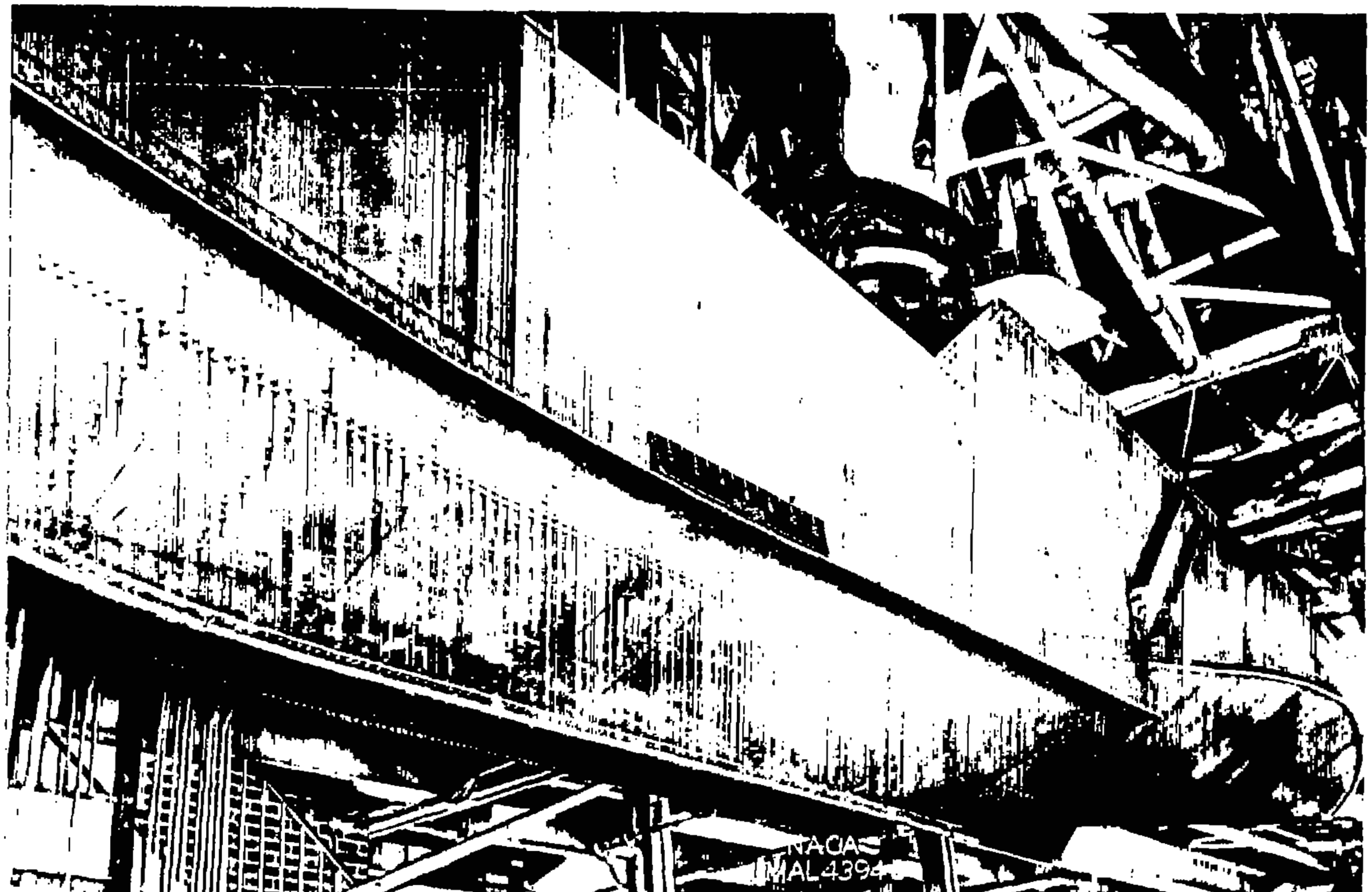

Figure 7.- Photograph showing several pressure gages flush-mounted in hull bottom.

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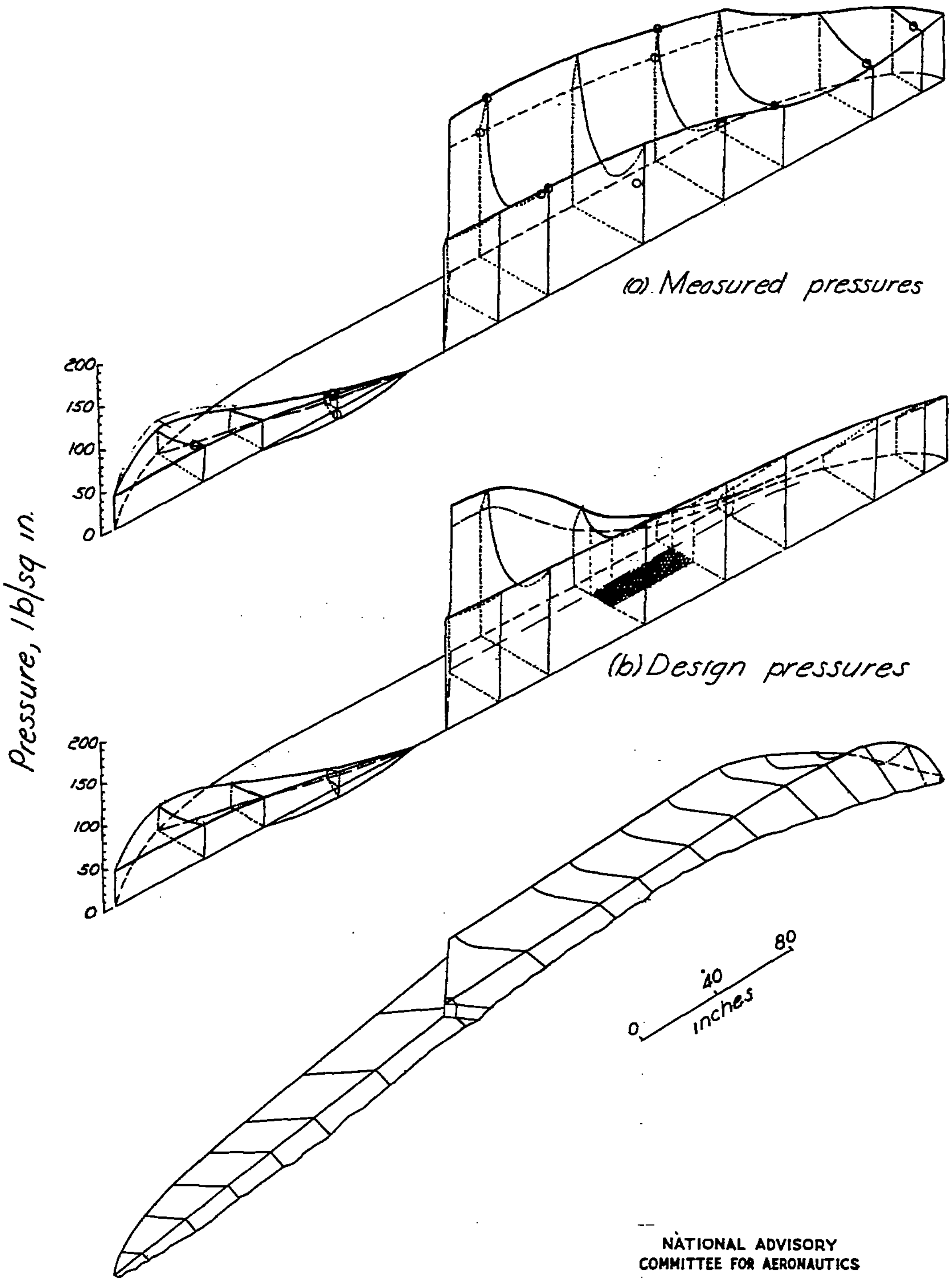

Figure 8.- Distribution of maximun local pressures on the XJL-1 float bottom (full scale values).

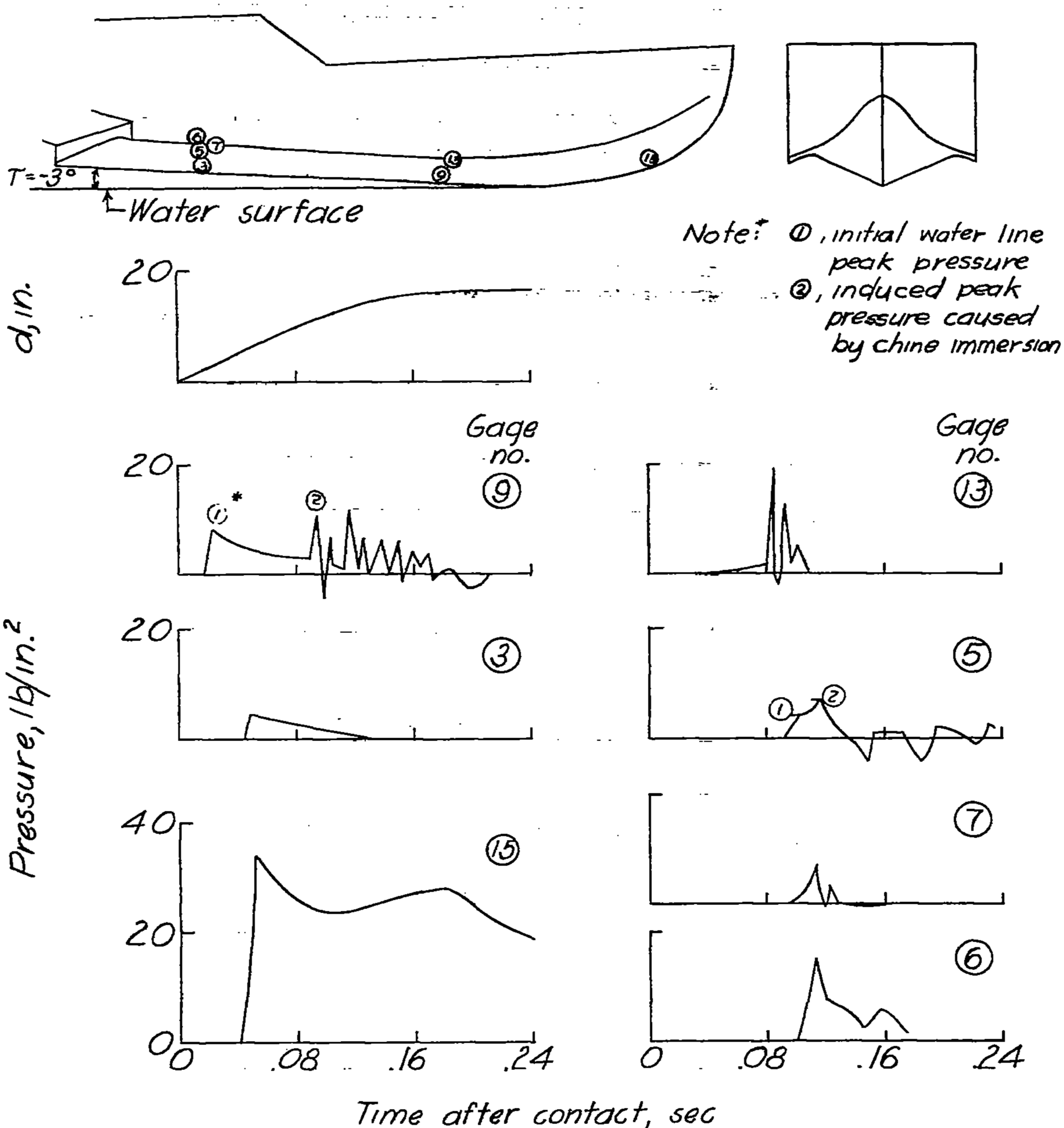

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Figure 9.– Time histories of pressures at different stations on XJL-1 bottom during impact 7; $\tau = -3^{\circ}$; $V_h = 126$ ft/sec; $V_v = 9.9$ ft/sec.

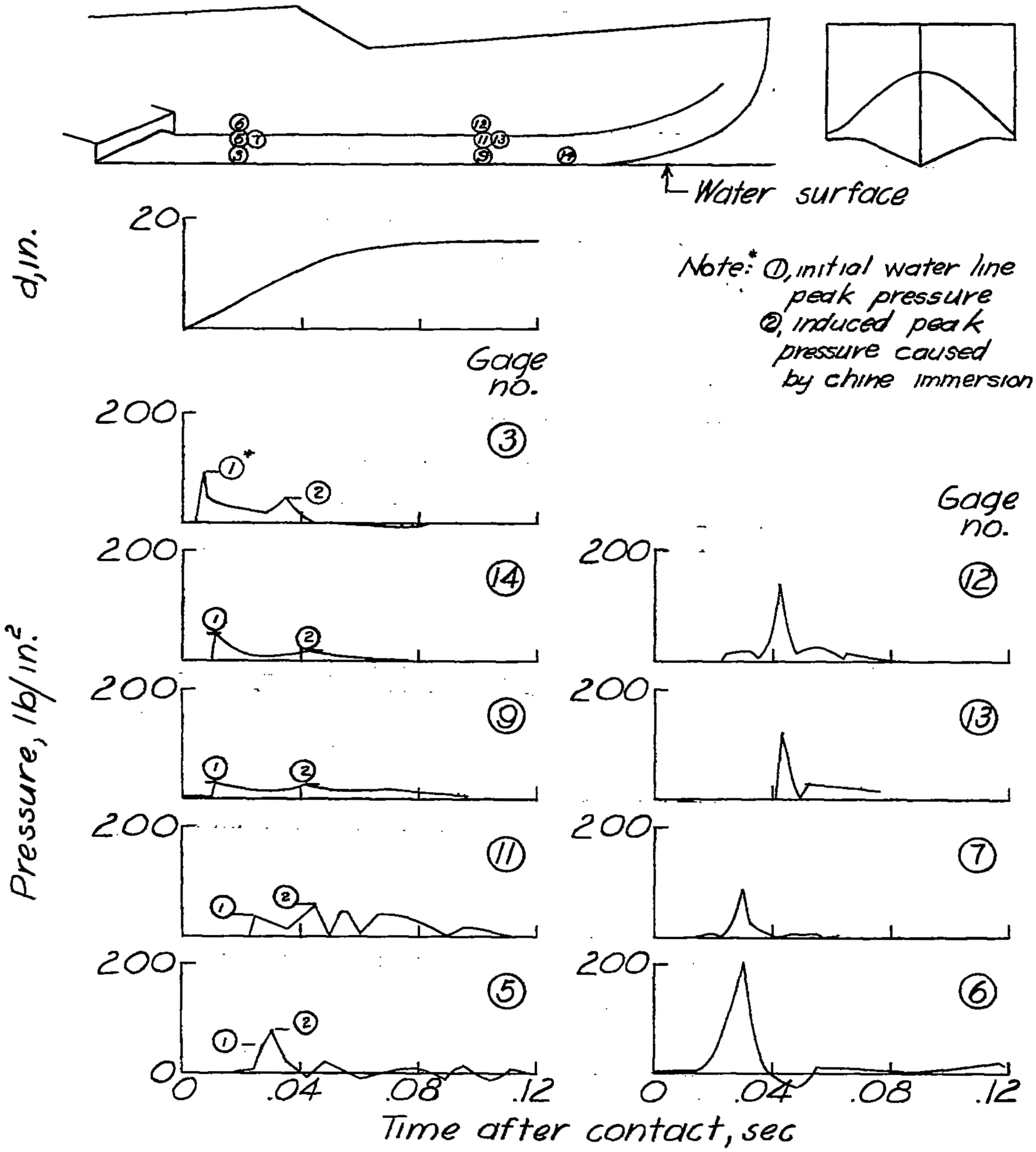

Figure 10.– Time histories of pressures at different stations on XJL-1 hull bottom during impact 15; $\tau = 0°$; $V_h = 126$ ft/sec; $V_v = 25.6$ ft/sec.

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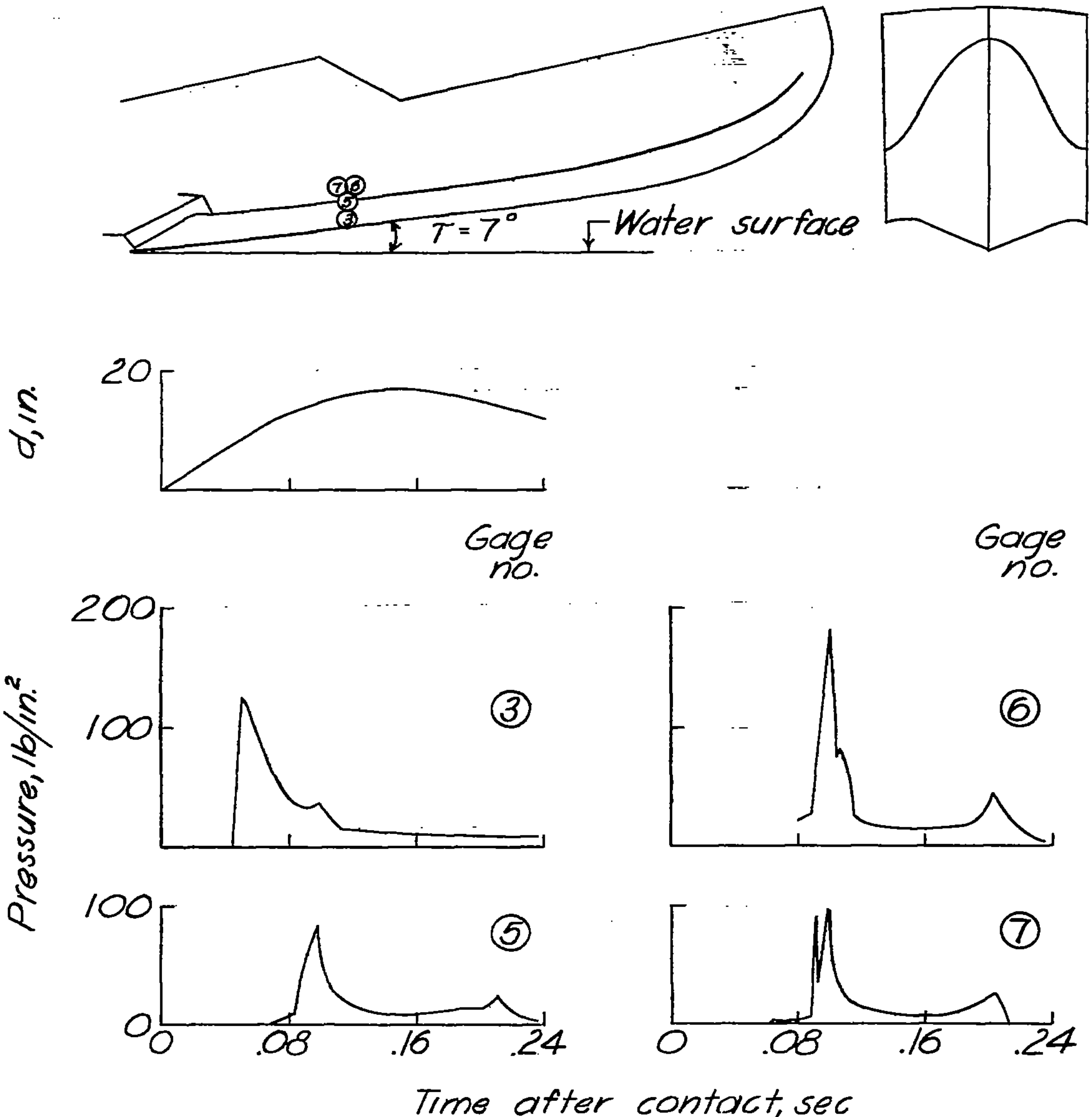

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Figure 11.- Time histories of pressures at different stations on XJL-1 hull bottom during impact 39; $\tau = 7^\circ$; $V_h = 126$ ft/sec; $V_V = 13.6$ ft/sec.

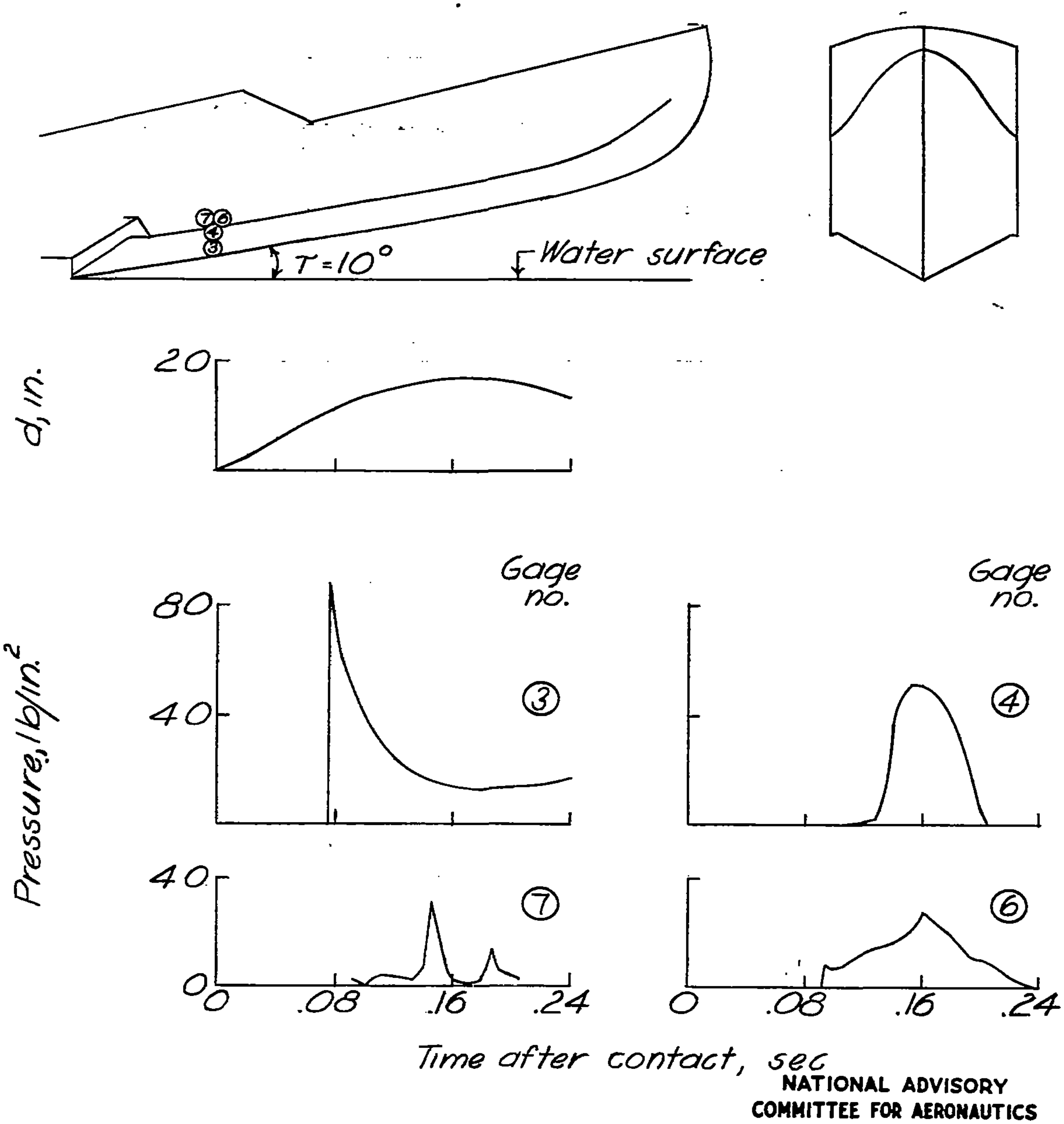

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Figure 12. – Time histories of pressures at different stations on XJL-1 hull bottoms during impact 44; $\tau = 10^\circ$; $V_h = 126$ ft/sec ; $V_v = 12.1$ ft/sec.

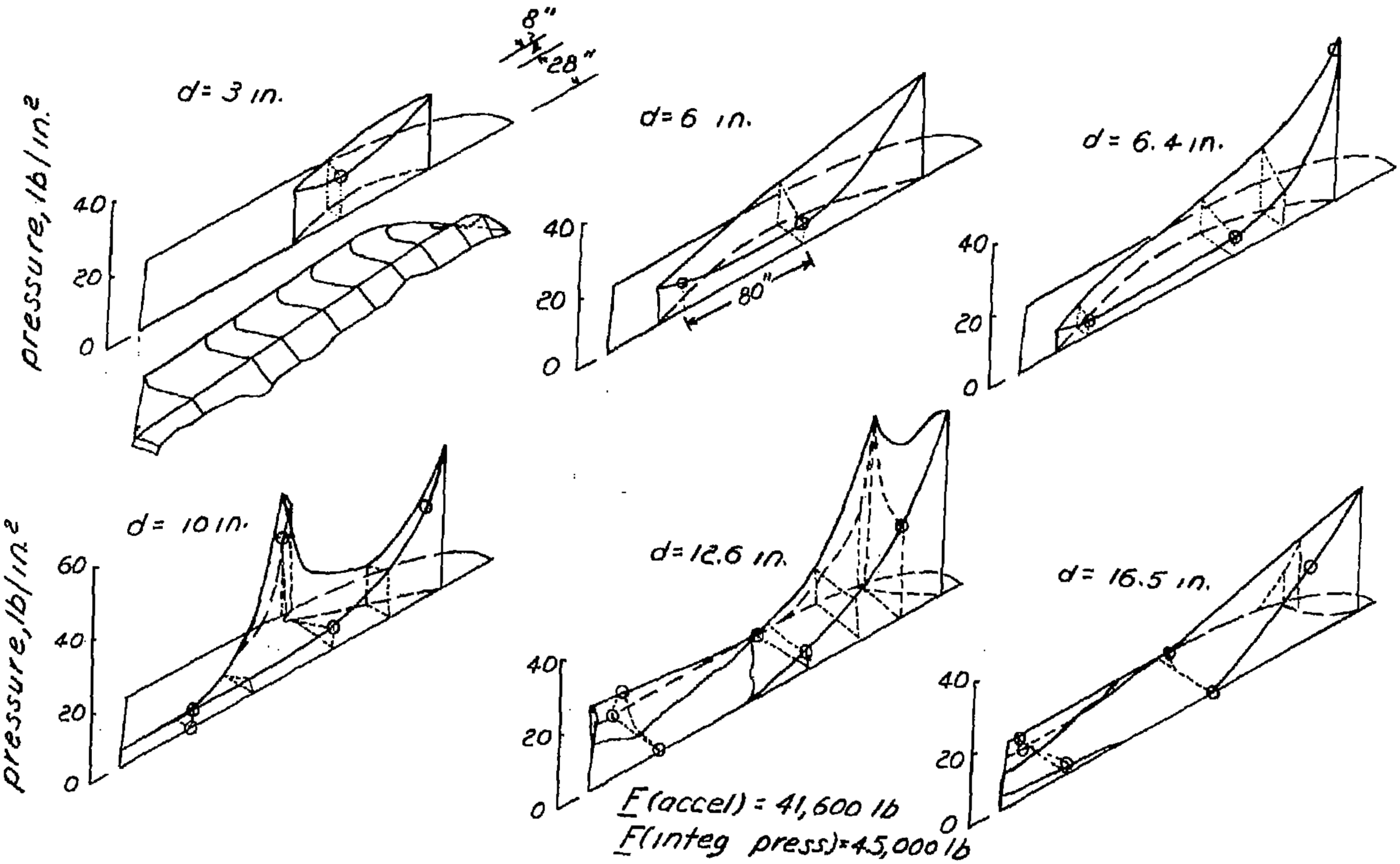

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Figure 13.- Instantaneous pressure distribution on XJL-1 float bottom; impact number 7; trim = -3°; V_h = 126 ft/sec; V_V = 9.9 ft/sec

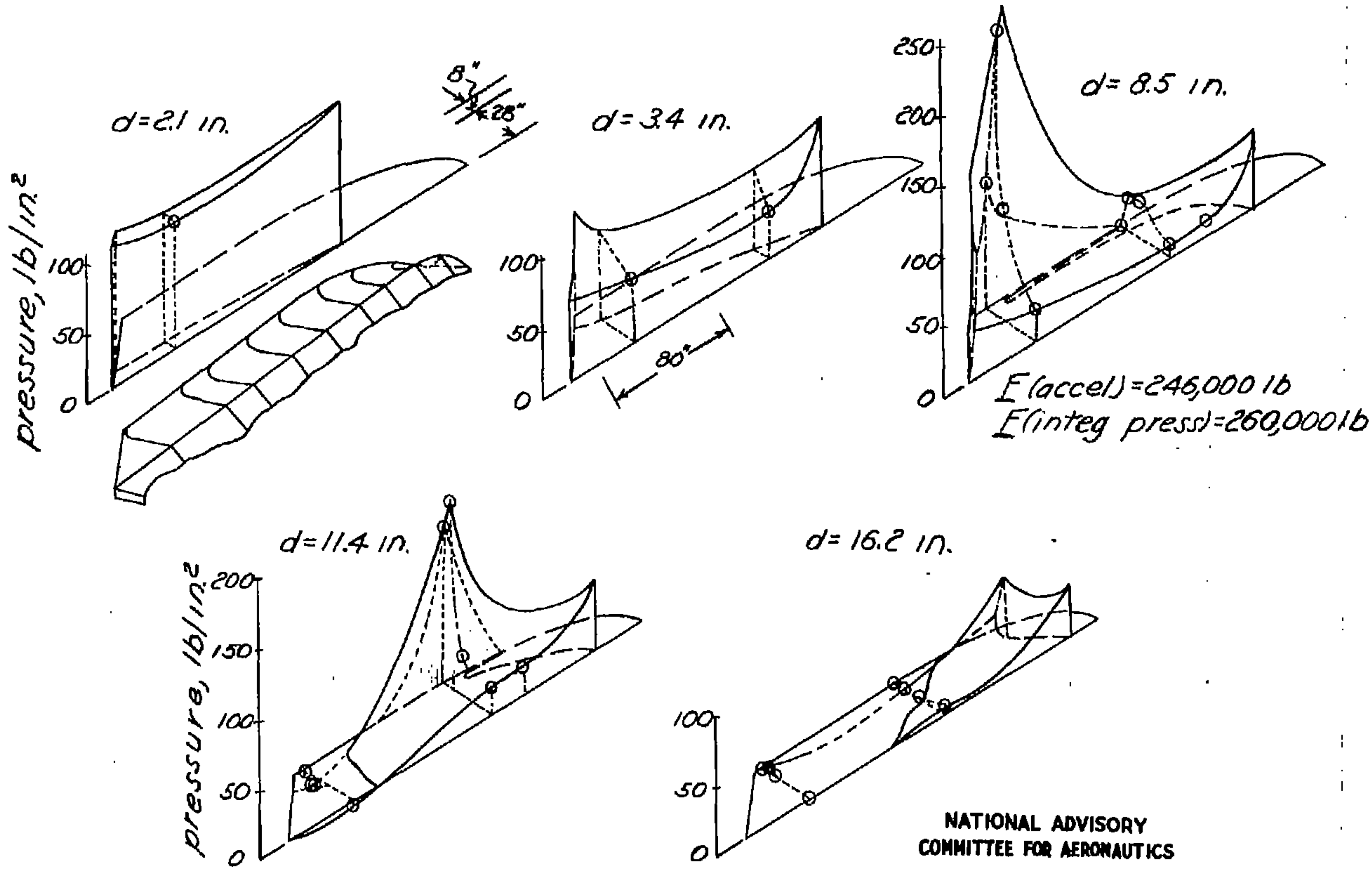

Figure 14.- Instantaneous pressure distributions on XJL-1 float bottom; impact number 15; trim = 0°; V_h = 126 ft/sec; V_v = 25.6 ft/sec.

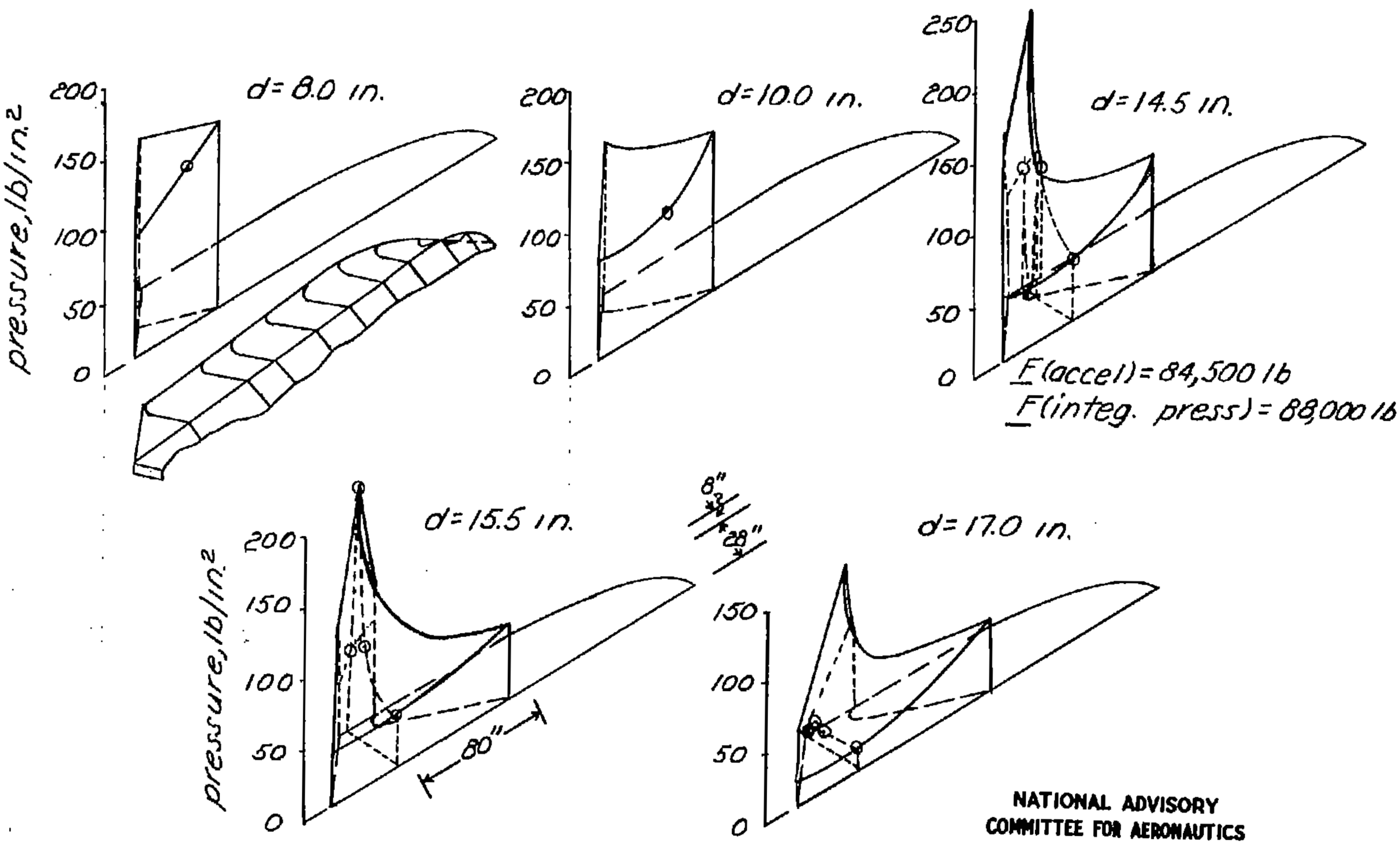

Figure 15.- Instantaneous pressure distributions on XJL-1 float bottom; impact number 39; trim=7°; V_h=126 ft/sec; V_v = 13.6 ft/sec.

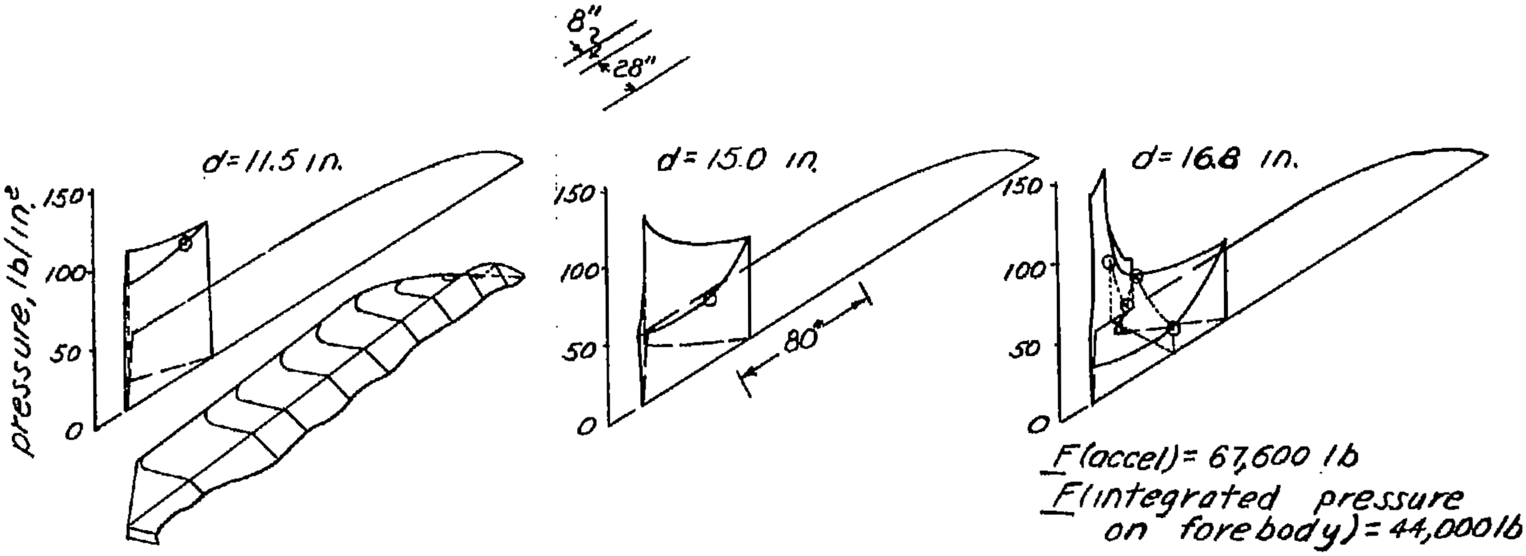

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Figure 16.- Instantaneous pressure distributions on XJL-1 float bottom; impact number 44; trim = 10°; V_h = 126 ft/sec; V_v = 12.1 ft/sec;

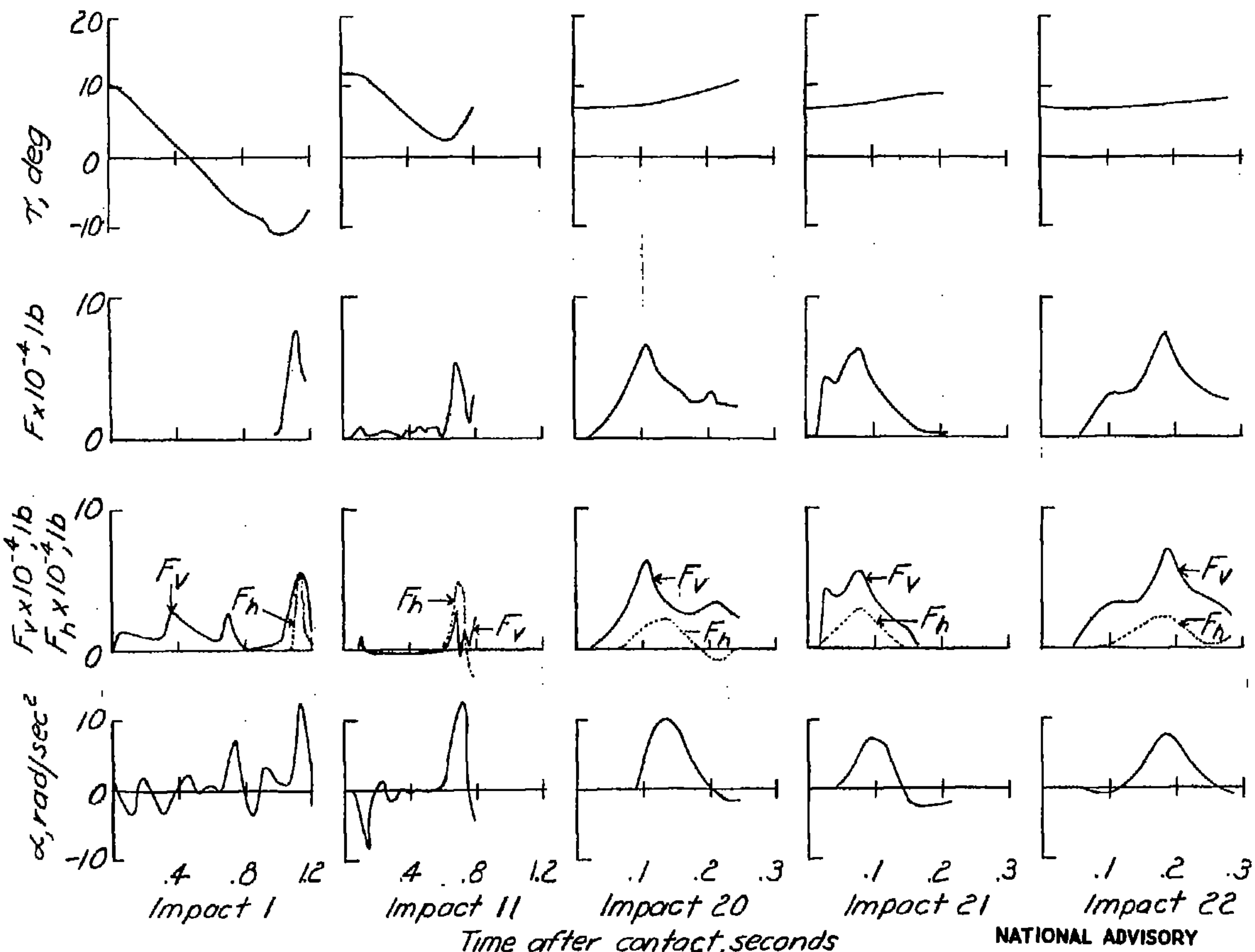

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Figure 17.-Time histories of resultant forces, pitching accelerations, and trims measured during free-to-trim tests.

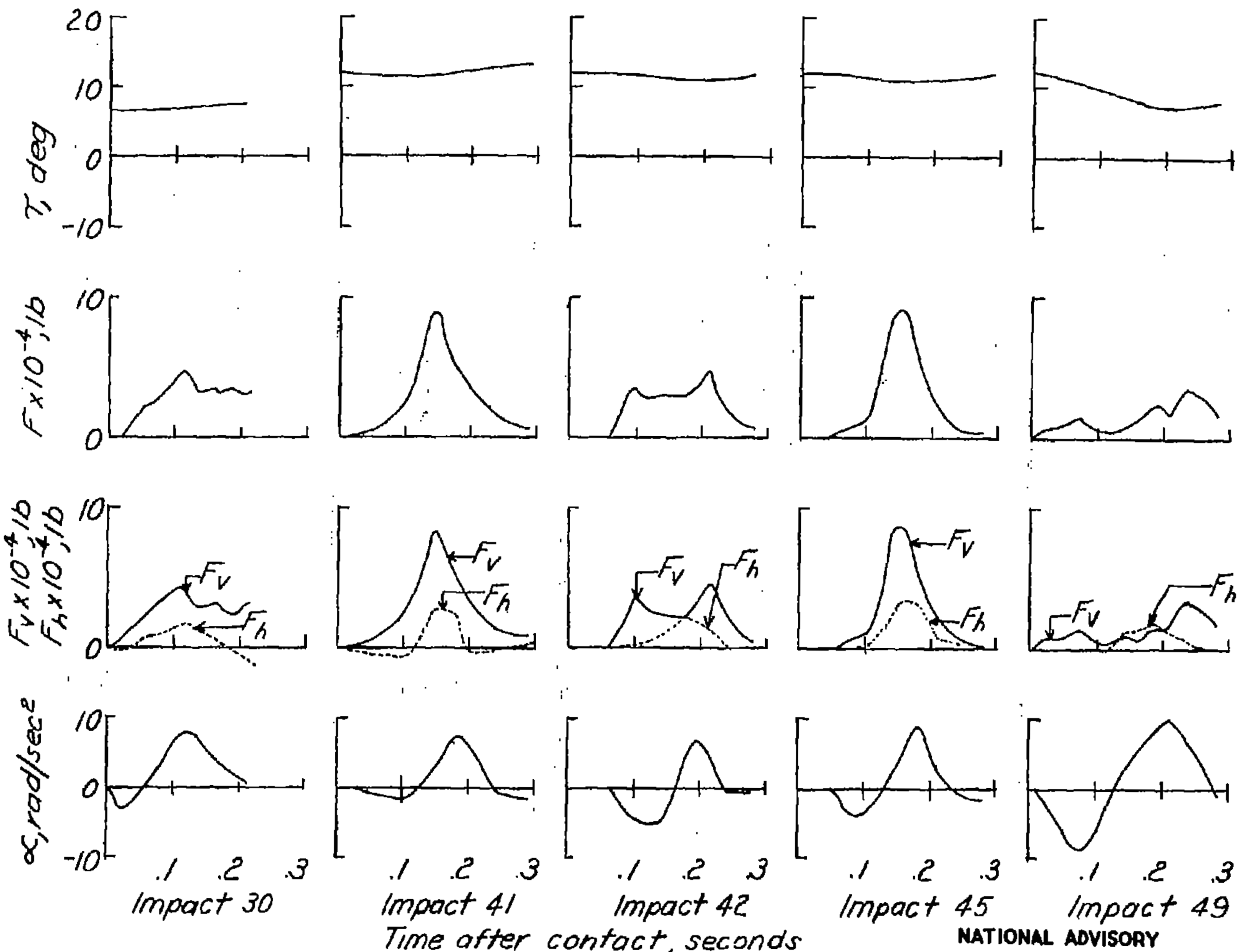

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Figure 18.–Time histories of resultant forces, pitching accelerations, and trims measured during free-to-trim tests.

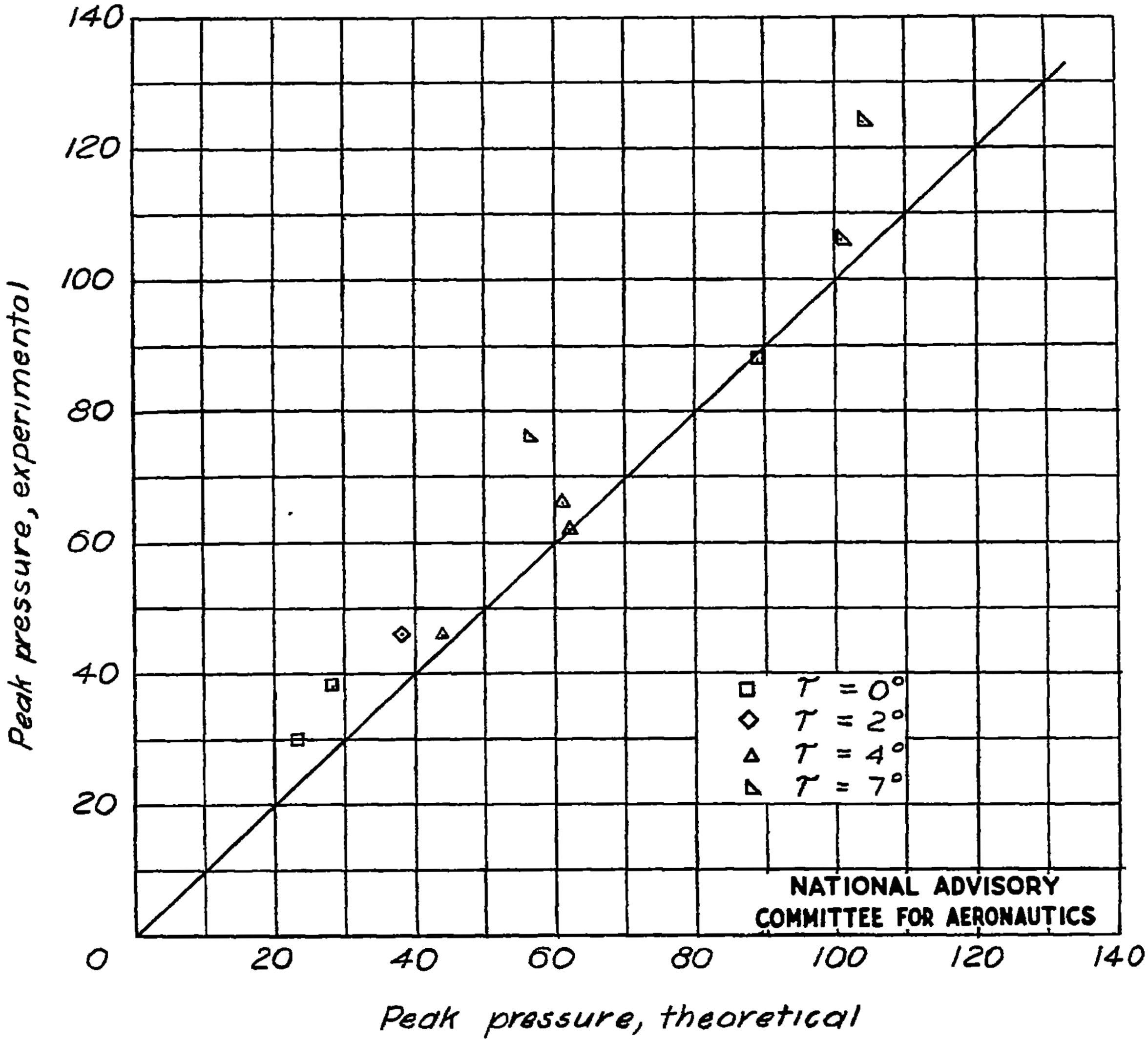

Figure 19.- Comparison of experimental and theoretical peak pressures on gage 3 for smooth water impacts of the XJL-1 float with fixed trim.

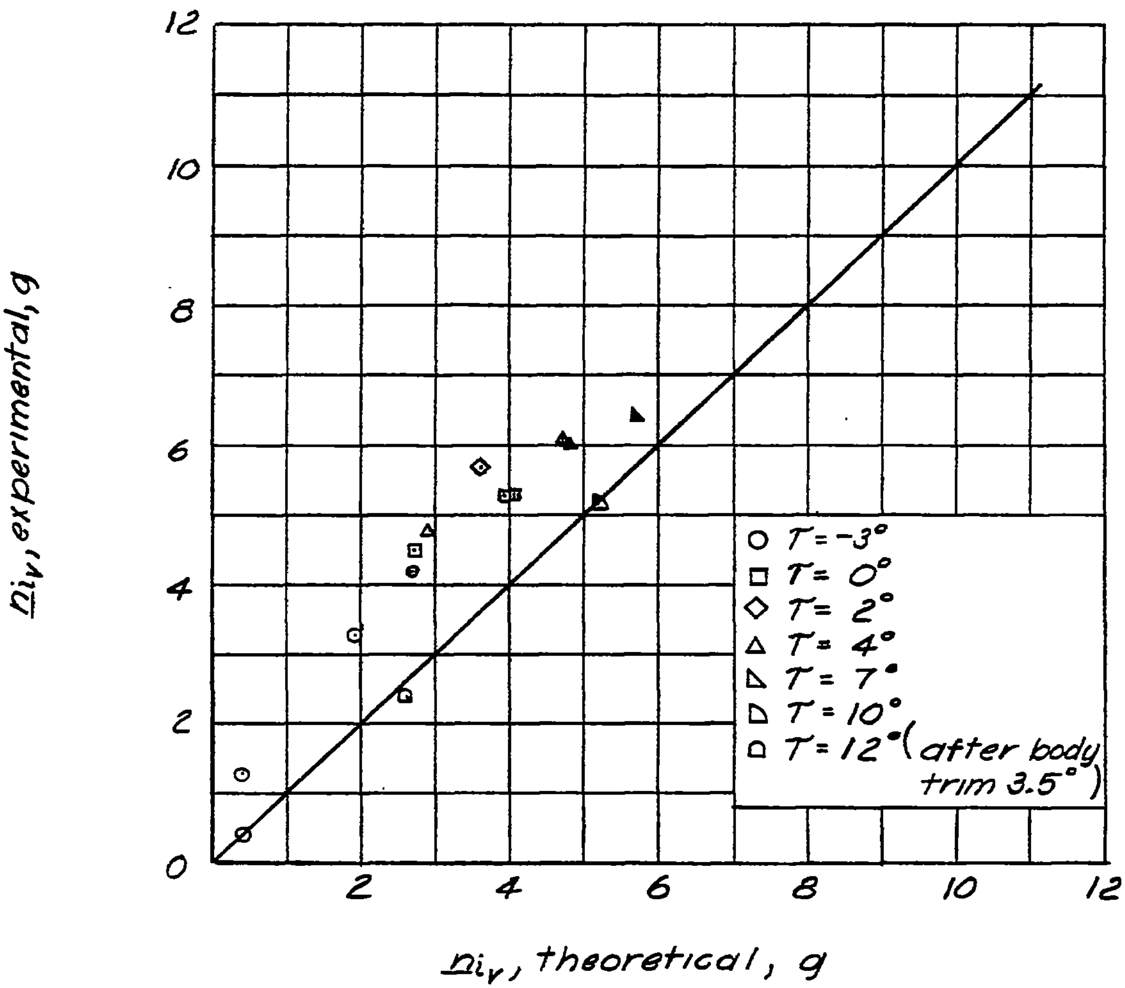

Figure 20 — Comparison of experimental and theoretical load factors for smooth water impacts of the XJL-1 float with fixed trim.

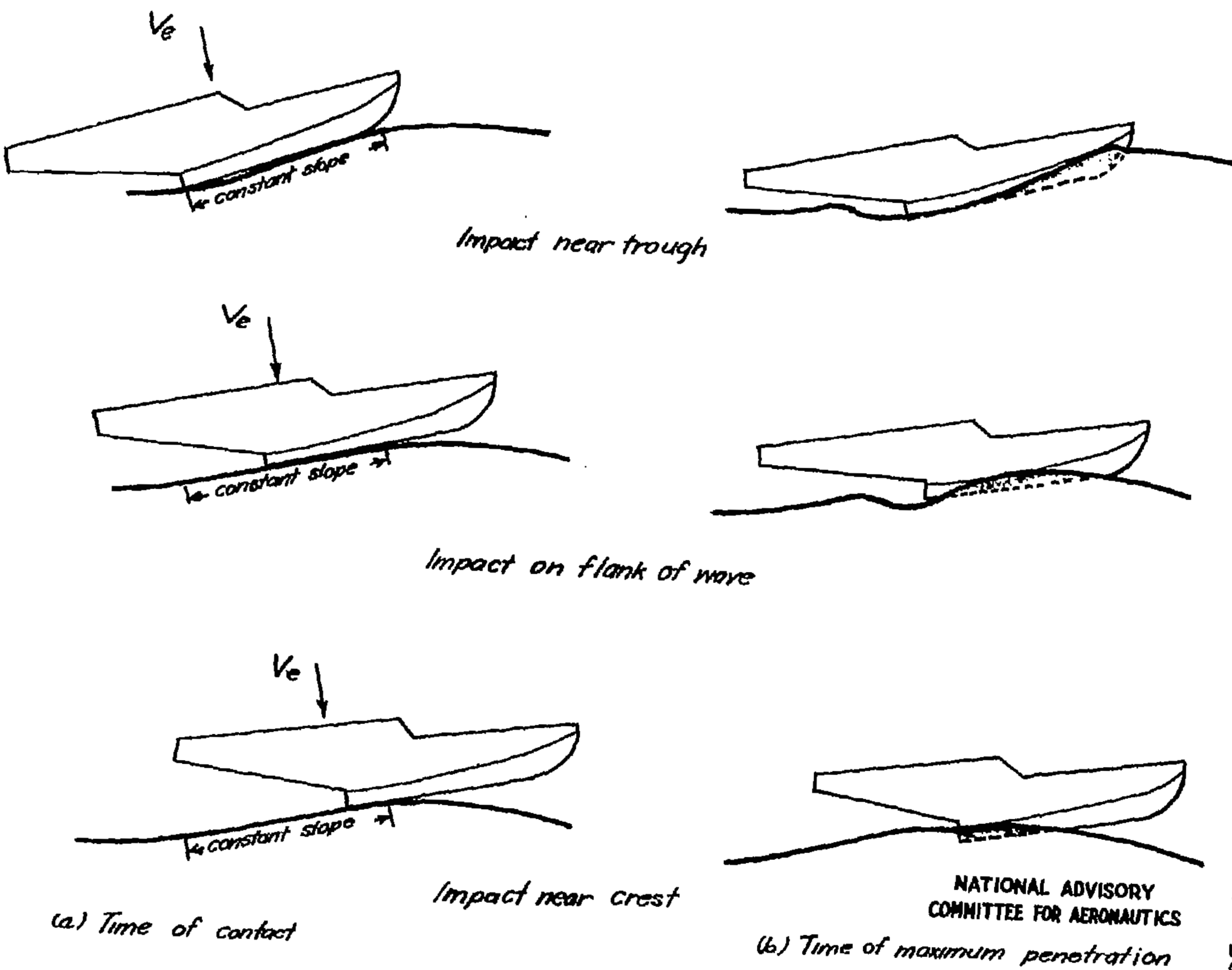

Figure 21.- Sketch showing three possible impacts having same velocity of penetration and trim relative to water slope but with different wetted areas involved at time of maximum immersion.